# “A COMPARATIVE STUDY BETWEEN LOCKING COMPRESSION PLATE AND NON LOCKING COMPRESSION PLATE IN THE TREATMENT OF INTRAARTICULAR CALCANEAL FRACTURE”

**DISSERTATION SUBMITTED FOR**
**MASTER OF SURGERY DEGREE EXAMINATION**
**(BRANCH – II, ORTHOPAEDIC SURGERY)**
**MARCH-2015**


**THE TAMILNADU**
**DR.M.G.R MEDICAL UNIVERSITY**
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# CERTIFICATE

This is to certify that the work entitled **"A comparative study between locking compression plate and nonlocking compression plate in the treatment of intrarticular calcaneal fracture"** which is being submitted for M.S. ORTHOPAEDICS, is a bonafide work of **DR.S. ESWARAPANDI**, post graduate student in the Department of Orthopaedics, Tirunelveli Medical College, Tirunelveli.

**DEAN**

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Tirunelveli.

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He has completed the necessary period of stay in the department and has fulfiled the conditions required for submission of this thesis according to the university regulations.The study was undertaken by candidate himself and observations recorded have been periodically checked by us.

Recommended and forwarded

**Prof. Dr. Elangovan Chellapa**
**M.S. Ortho, D. ortho,**
**Professor and Head,**
**Department Of Orthopaedics,**
**Tirunelveli Medical College,**
**Tirunelveli.**

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This is to certify that the Institutional Ethical Committee of this College unanimously approves the Thesis /Dissertation/ Research Proposal submitted before this committee by Dr. S. Eswarapandi, PG in Ortho, Department of ORTHO, Tirunelveli Medical College /Hospital, Tirunelveli titled **"COMPARATIVE STUDY BETWEEN LOCKING COMPRESSION PLATE AND NONLOCKING COMPRESSION PLATE IN THE TREATMENT OF INTRAARTICULAR CALLANEAL FRACTURE"** registered by the IEC as 270/ORTHO/IEC/2012 dated. 14.12.2012. The Investigator is hereby advised to adhere to all the stipulated norms and conditions of this ethical committee.

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**14.12.2012**

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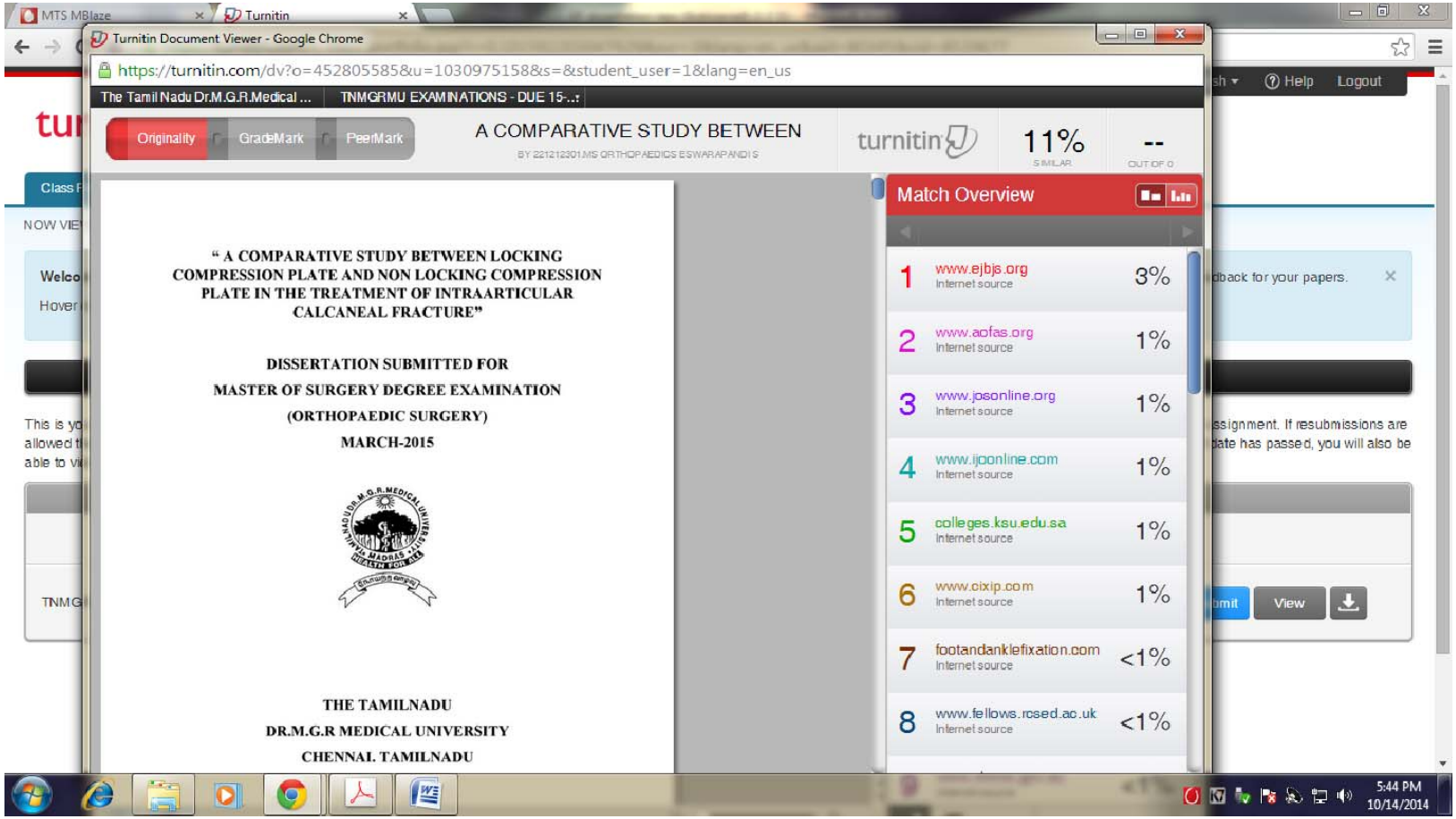
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# DECLARATION

I **Dr.S.Eswarapandi**, solemnly declare that the dissertation titled **"A COMPARATIVE STUDY OF LOCKING COMPRESSION PLATE AND NONLOCKING COMORESSION PLATE IN THE TREATMENT OF INTRAARTICULAR FRACTURES OF CALCANEUM"** has been prepared by me. This is submitted to **"The Tamilnadu Dr. M.G.R. Medical University, Chennai"**, in partial fulfilment of the regulations for the award of MS degree Orthopaedics.

**Place : Tirunelveli** **Dr. S.ESWARAPANDI**

**Date**

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**Last but not least, I express my gratitude to the patients for their kind co-operation.**

# A COMPARATIVE STUDY BETWEEN LOCKING COMPRESSION PLATE AND NONLOCKING COMPRESSION PLATE IN THE TREATMENT OF INTRAARTICULAR CALCANEAL FRACTURE


## ABSTRACT

**Background:**

In a prospective study we analysed intra-articular calcaneal fracture treatment by comparing results and complications related to frature stabilization with locking and nonlocking compression plates.

**Materials and Methods:**

Our study 23 osteosynthesis(20 patients) of intra articular calcaneal fracture using the standard extensile lateral approach from July 2012 to July 2014.10 operation using locking plate,10 operation using nonlocking compression plate.In the Sanders type 4 fractures,reconstruction of the calcaneal shape was attempted .The patients were evaluated by the AOFAS Ankle Hindfoot Score.

**Results:**

Wound healing complication,late subtler arthritic changes high in nonlocking compression plate.preoperative size of Bohlers,Gissanes angle correlated with post operativ and one year follow up clinical and radiological results in both groups.There were no late complications in locking compression plate group.All the late complication occur in the nonlocking

compression group.The overall results according to the AOFASankle Hindfoot Score were LCP group better than the NONLOCKING group.

**Conclusion:**

Open reaction and internal fixation of intraarticular calcaneal fractures has become a standard surgical method.Fewer complications and better results related to treatment with locking compression plates confirmed in comparison to nonlocking ones were noted for all Sanders type of intraarticular calcaneal fractures

## CONTENTS

# INTRODUCTION

The calcaneum or Os Calcis is a unique bone, with a unique mechanism of fracture. The most frequently fractured bone of the foot is the calcaneum. Calcaneal fractures commonly occur in young active male and industrial workers[9]. The burden to the society is significant with the socioeconomic impact being substantial in the terms of days away from work and recreation.

Till the end of 19$^{th}$ century calcaneal fractures were treated nonoperatively with rest and limb elevation[8].

The advent of advanced imaging modalities that kindled desire of restoring the distorted anatomy of this bone. The operative treatment of calcaneal fractures includes percutaneous k-wire, percutaneous screw, non-locking compression plate and locking compression plate.

The controversy between the operative and nonoperative interventions remains ongoing subsequent analysis and other related publictions has pushed the pendulum towards the surgical option1[14].

More high level research is needed towards determining exactly which operative exposures, techniques, instrumentations and other parameters are ideal. The advent of CT scan provides information regarding size and number of fracture fragments, sustentaculum displacement relative to the supromedial fragment, posterior facet congruity, lateral malleolus

impingement on the tuberosity[22] and hence a newer classification system with prognostic significance.

In our study we have tried to compare the outcome between the locking compression plate and nonlocking compression plate in the treatment of intrarticular calcaneal fractures admitted during the period from july 2012 to july 2014 at Tirunelveli medical college hospital, Tirunelveli.

# AIM

To compare the clinical, radiological and functional outcome between the locking compression plate and nonlocking compression plate in the treatment of intra articular calacaneal fractures.

## EPIDEMIOLOGY

Calcaneal fractures represent only 2% of all fractures of adult population[6] and 75% fractures of foot and the extraarticular fractures represent upto 60% of calcaneal fracture in children and their incident has been reported to be 25% to 40% of adult calcaneal fractures[9].

## ANATOMICAL CONSIDERATIONS

The Os Calcis is described as an irregular bone ,predominantly cancellous in structure and enveloped in the a shell of thin cortical bone. It represents the largest bone of the seven tarsal bones.

Calcaneum possess six surfaces and articulate with two bones talus and cuboid. The anterior surface articulate with the cuboid, its saddle in shaped.

### Anterior Surface

It is the smallest surface. It is obliquely placed and saddle shaped. Its articular facets articulates with cub

### Posterior Surface

The Posterior surface is divided into three parts, the proximal area which is separated from tendo Achilles by a bursa and fibro fatty tissue, the middle part which gives attachment to the Achilles tendon and the distal part which is the subcutaneous weight bearing surface.

## SUPERIOR SURFACE (FIG 1)

The superior surface articulates with the talus. The superior surface is divided into posterior, middle and anterior facets. Posterior facet is inclined to the saggital plane at 45 degree and the middle facet articulate with the talar head and neck and it lies on the sustentaculum tali. Anterior facet located over the anterior end of the superior surface and articulates with anterior talar facet and it rests on the beak of calacaneum. Between the posterior and middle facets lies the calcaneal sulcus which together with the similar groove on the talus forms the sinus tarsi. Sinus tarsi lodges the artery of the sinus tarsi and the intraosseous talocalcaneal ligament. Anterior to the anterior facet the bifurcate y ligament is attached and lateral to it is the origin of extensor digitorum brevis.

The posterior subtalar joint which is the primary weight bearer is located in the middle of the superior surface. It is supported by the strong compression trabeculae under the surface of compression trabeculae called the thalamic portion of the bone. Posterior subtalar joint is saddle shaped joint and supports the eversion inversion of the foot.

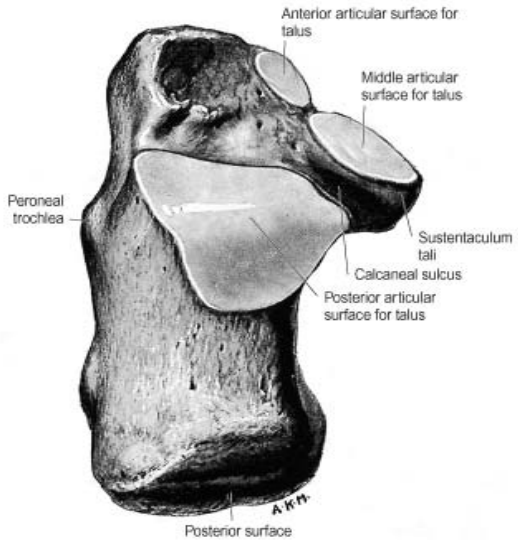



Fig 1:Superior Surface

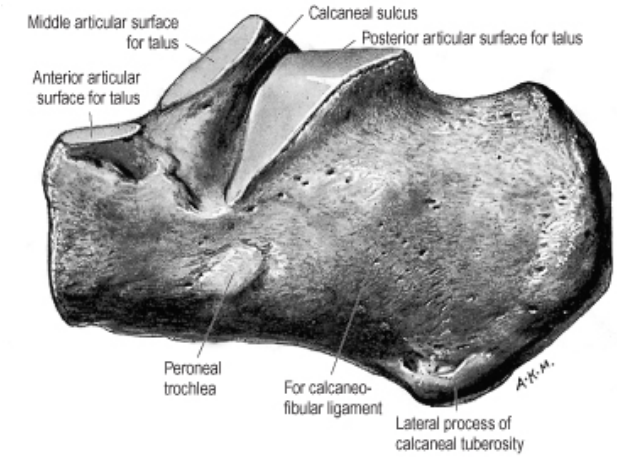



Fig 2: Lateral Surface

**Lateral Surface (fig 2)**.

This surface is subcutaneous and flat and palpable beneath under lateral malleolus. An elevation located 2cm distal to lateral malleolus is peroneal tubercle. Peroneal tubercle serves as an insertion for peroneal retinaculum. Calcaneal tubercle is above and behind the trohlea it gives attachment to calcaneofibular ligament.peroneus longus and brevis tendon is

separated by the peroneal trochlea to which the inferior peroneal retinaculum is attached

**Medial Surface (Fig 3)**

On the anterosuperior aspect of its medial surface is larger and stronger, sustentaculum tali groove for tibialis posterior tendon and flexor hallusis longus, is inferior to the sustentaculum tali. The flexor accessories medial head is inserted to the distal to this groove. The intraosseous ligamen,plantar calcaneo navicular ligament,anterior fibers of the deltoid ligament and the medial talocalcaneal ligament holds the talus medial to the calcaneum

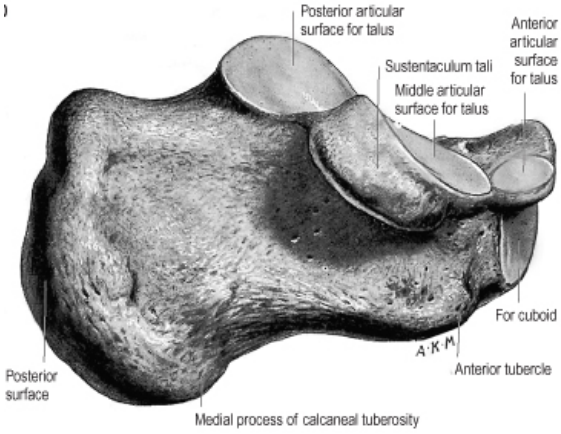



Fig 3: Medial Surface

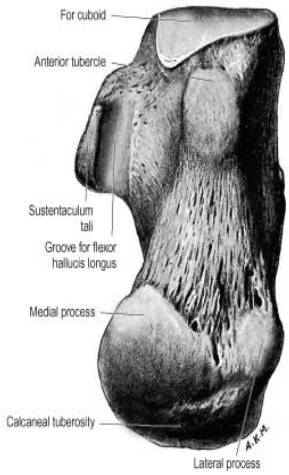



Fig 4: Inferior Surface

**Inferior Surface (Fig 4)**

On the plantar or inferior surface at its posterior end lies the calcaneal tubercle. Whose medial process gives the origin of the abductor hallucis and flexor digitorum brevi,its lateral process to abductor digiti quinti and the central part to plantar aponeurosis and quadratus plantar muscle

## SOFT TISSUE RELATIONS

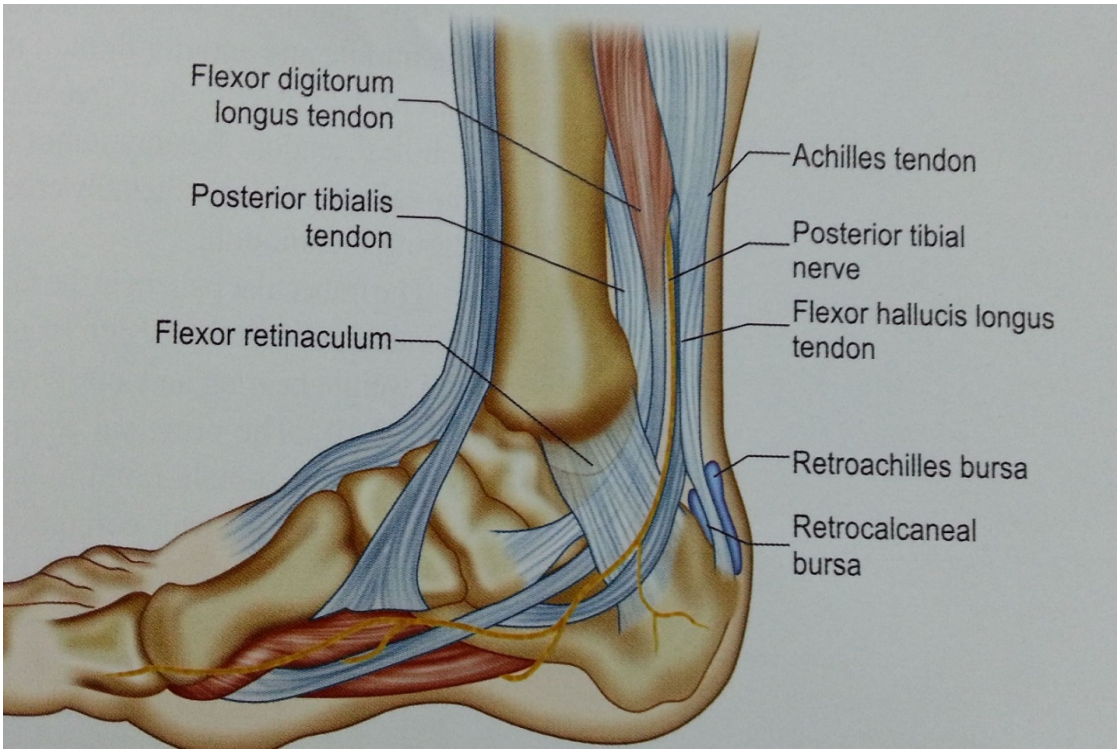



Fig 5 .Soft tissue in relation to the medial surface of the hind foot

The interosseous talocalcaneal and cervical ligaments and medial root of inferior extensor retinaculum are attached to the calcaneal sulcus. The nonarticular area in the distal part of the posterior facet gives attachment to the extensor digitorum brevis, inferior extensor retinaculum and bifurcated y ligament[6].

The sustentaculum gives attachment to flexor retinaculum. The plantar calcaneo ligament is attached to the medial margin[9].

The long plantar ligament orginates between the medial and lateral process. It extends to the tubercle distally. The lateral head of the flexor accessories is attached to the lateral margin of long plantar ligament.

## BLOOD SUPPLY[9]

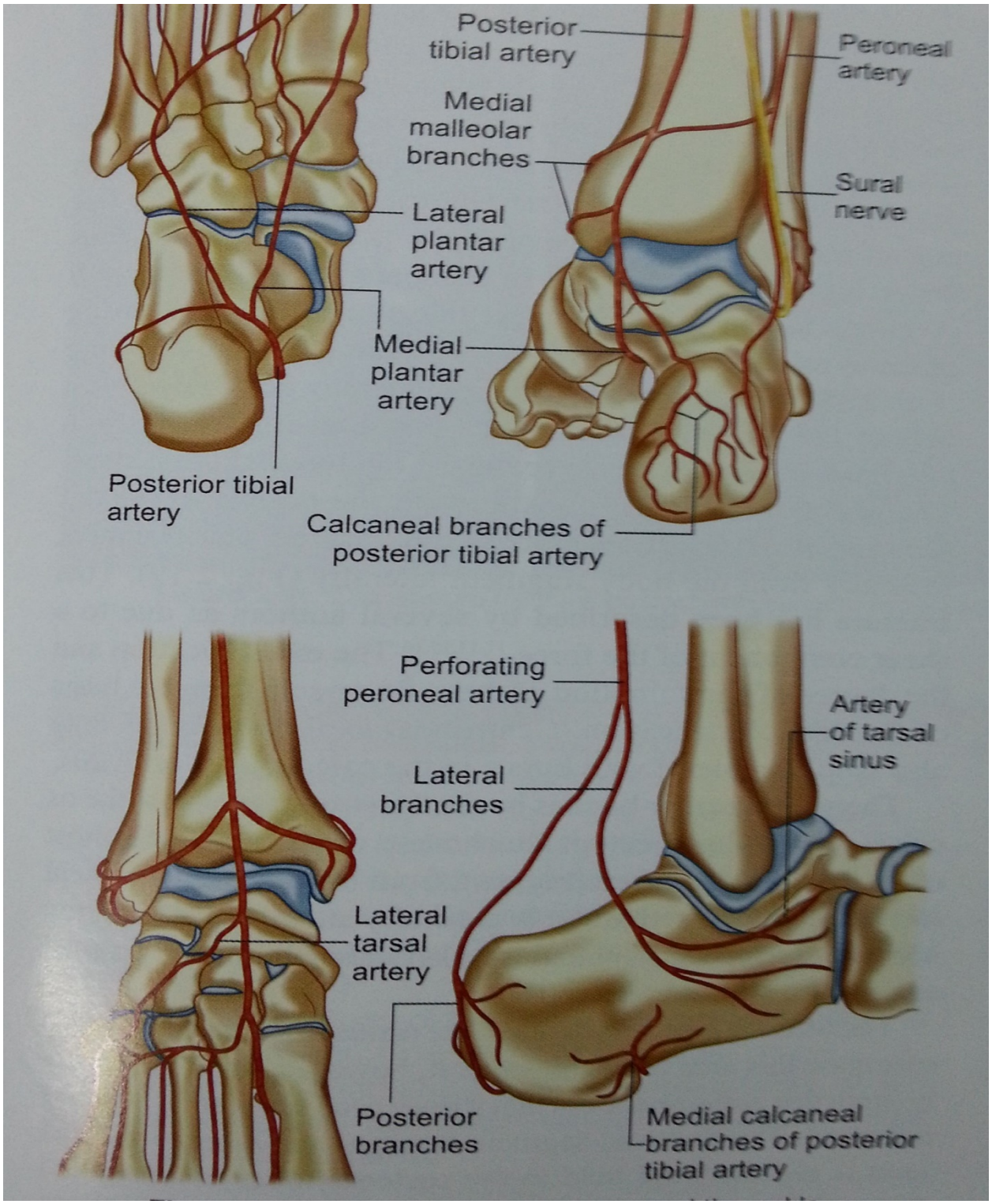



**Fig 6. Blood supply of foot showing calcaneal supply**

Avascular necrosis of the calcaneum is rare compared to that of the talus due to profuse muscular, tendinious, ligamentous attachments.

Vascular anastomosis from

1. Posterior tibial artery gives branches to medial and lateral plantar arteries.
2. Anterior tibial artery gives branches to medial and lateral malleolar arteries.
3. Perforating branch of the peroneal artery.

**NERVE SUPPLY**

The branches of tibial,sural and deep peroneal nerves innervates the calcaneum[6].

**OSSIFICATION**

Calcaneum ossifies from one primary during the third month of intrauterine life. One secondary center which appears at six to eight years ,at 14- 16 years secondary centre fuses[6].

## MECHANISM OF INJURY

Calcaneal fractures with intraarticular involvement and displacement can occur due to high velocity injury which usually is due to fall from height. In this mode of injury the patient's weight is concentrated on the heels on axial loading. Other mode of injuries like high velocity injuries are due to motor vehicle accidents. Axial load injuries are associated with spine and pelvic injuries. The pattern of communition and the location of the fracture lines are dependant on the position of foot at the time of impact, the forces of impact and bone quality.

According to Carl et al two primary fracture lines were consistently observed. One line divided the calcaneum to medial and lateral portion. The other fracture line divided the calcaneum into anterior and posterior portions, starting laterally from angle of Gissane running medially. These two fracture lines resulted in a variety of tongue and joint depression type fractures

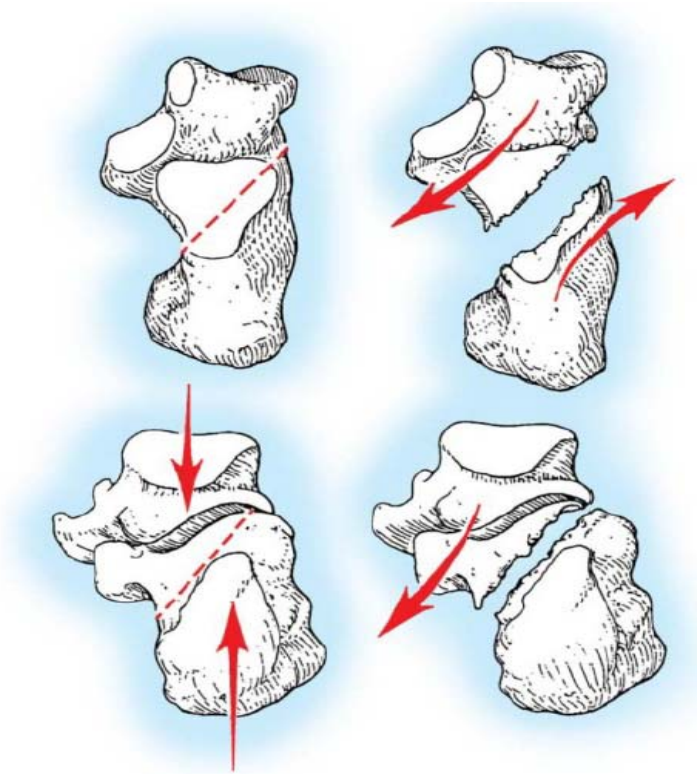


Fig 7.1:  The primary fracture line.

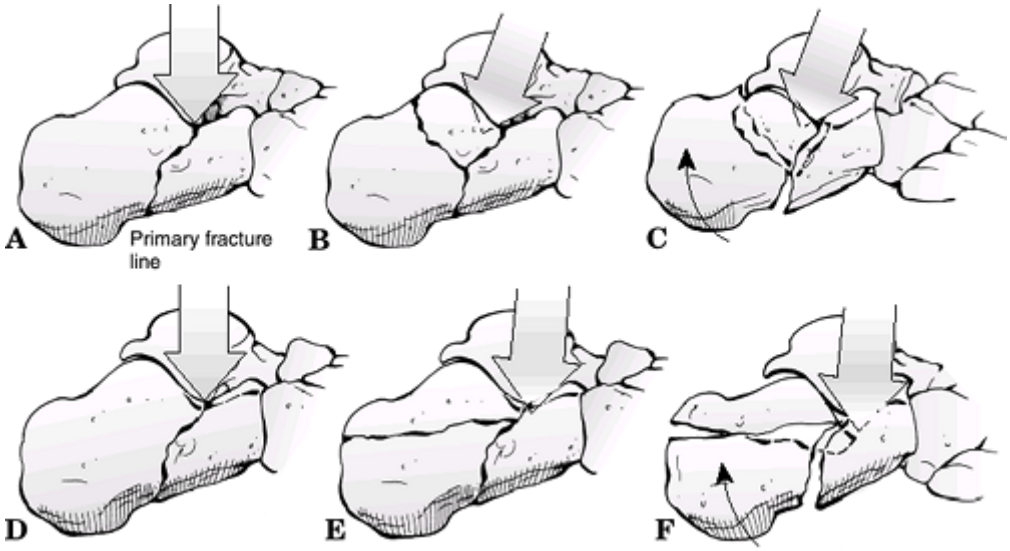



Fig 7.2: Mechanism Of Injury.A-C Joint depression type. D-F Tongue type

## CLASSIFICATION

Calcaneal fractures initially classification based on conventional radiographs but posed difficulties in planning treatment. Nowadays CT based classifications, treatment has improved.

**ESSEX-LOPRESETI (1952)**

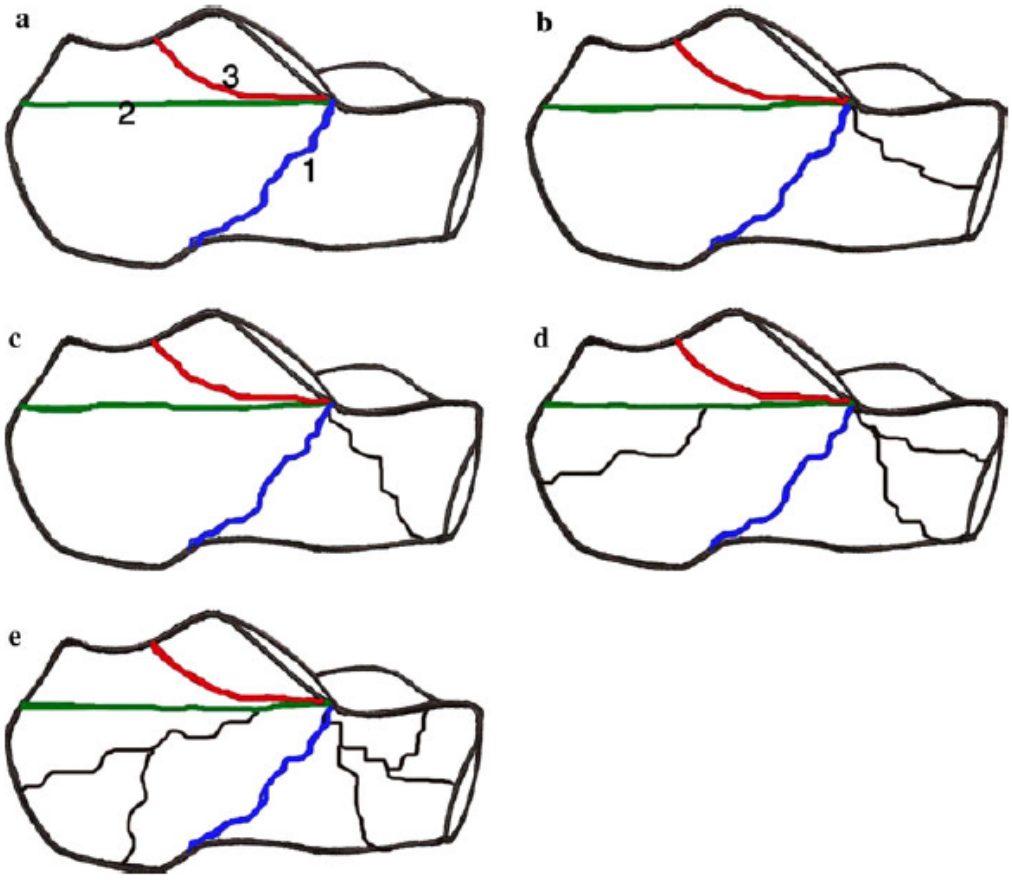



Fig 8: Essex- Lopresti Classification. Line 1 represents primary shear fracture, Line 2 –secondary compression fracture giving the tongue fragment, Line 3- secondary compression fracture of the joint depression type.

**TONGUE TYPE FRACTURE**: the articular fragment remain attached to the tuberosity fragment.

**JOINT DEPRESSION TYPE**: The articular fragment was separate from the adjacent tuberosity.

**SHOEUR AND REMY (1975)** : based on the number of articular bony fragments.

**FIRST DEGREE**: undisplaced shear type fractures with separation of joint surfaces .

**SECOND DEGREE**: includes secondary fracture lines and a minimum of three fragments , of which two should include the articular surface.

**THIRD DEGREE**: Highly communited fractures.

**CROSBY AND FITZGIBBONS**

**TYPE I** –Undisplaced

**TYPE II** - Displaced

**TYPE III** - Communited

**SANDERS (CT Based)**

This classification refers to intra-articular fractures and was developed in 1993 after following 120 patients for a minimum of 1 year. It utilizes the axial and coronal hindfoot CT cuts. The planes of reconstruction are the semicoronal(perpendicular to posterior facet ) and the axial ( parallel to the sole of foot). The cut showing the widest part of the undersurface of the posterior facet of the talus is taken into consideration and this is divided into three equal columns by two lines ( A & B). Another line C that is drawn from the medial edge of the posterior facet of the talus, divides the corresponding calcaneus from the sustentaculum. Thus the entire calcaneus is divided into four segments : lateral, central, medial and sustentaculum segments. Four types of fractures are then described according to the number and location of the fracture fragments(fig 9).

**TYPE I**– Undisplaced fractures with less than 2mm displacement regardless of fracture lines

**TYPE II**- Two part fractures of the posterior facet. Based on the location of the primary fracture line.It is further divided into three types IIA, IIB, IIC.

**TYPE III**- Three part fractures of the posterior facet. Usually centrally depressed fragment further its divided into three types based on the primary fracture line. Types IIIAB, IIIAC, IIIBC.

**TYPE IV** – Highly communited 4 parts articular fragment. Often had more than four articular fragments

Universally Sander classification is most commonly used. In our study we have followed sanders for planning our treatment.

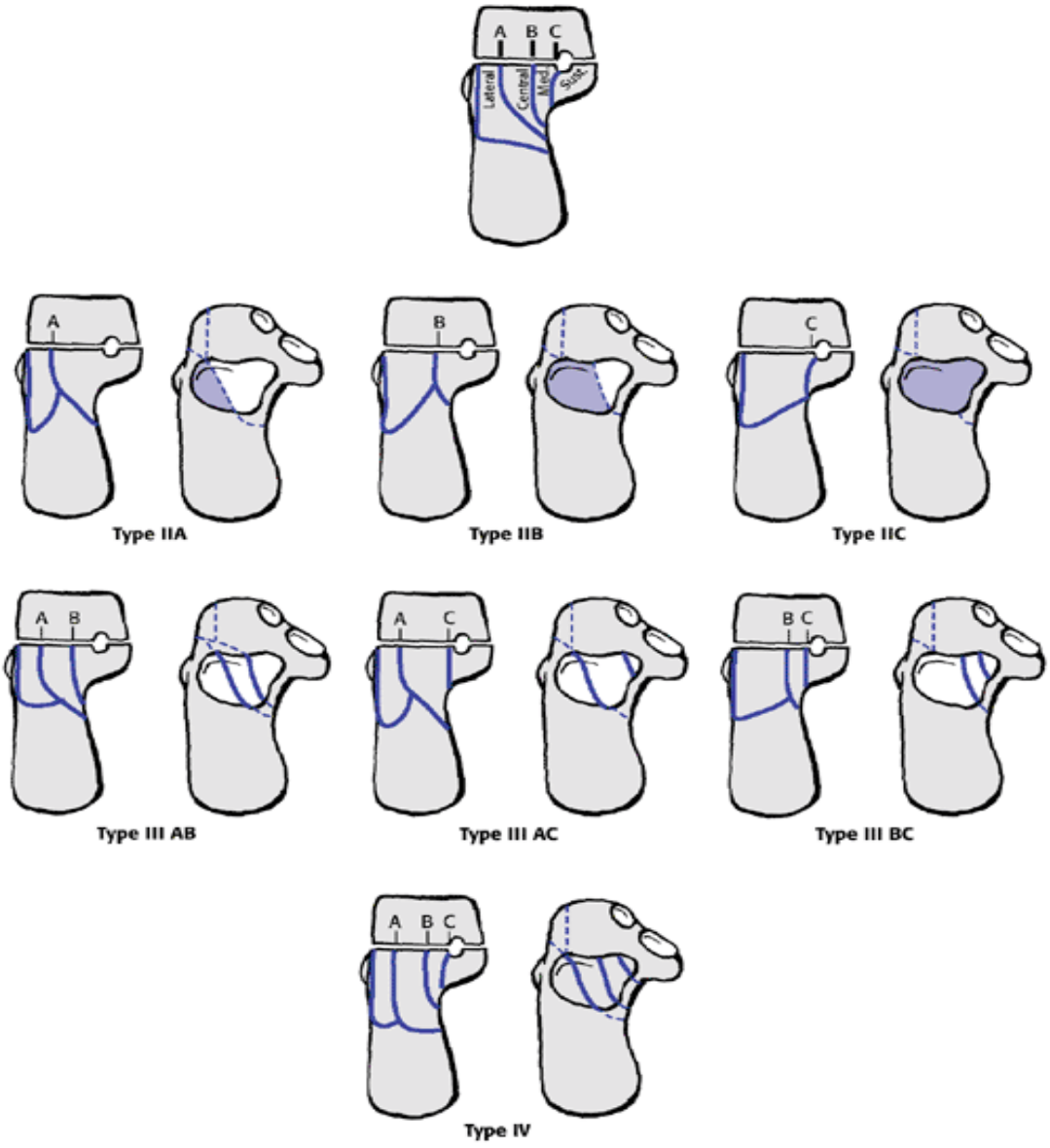



**Fig9: Sander's classification.**

## RADIOLOGICAL ANATOMY

Calcaneum is an important bone as it transmits the body weight to the ground and also helping the calf muscle action by creating a strong lever. Traction trabeculae extending from the inferior cortex of calcaneum converges over the compression trabeculae supporting the posterior and anterior articular facets.

The area under the thalamic segment of the bone with relatively sparse trabeculae called neutral triangle (refer fig 10). This area is considered to be of little significance in the pathological anatomy of fractures. But when the posterior subtalar joint is depressed the vacuous neutral triangle might fail to support the articular surface even after it has been elevated to its original state. The adjuvant is in favour of grafting in the region in the depressing fractures affecting this area.

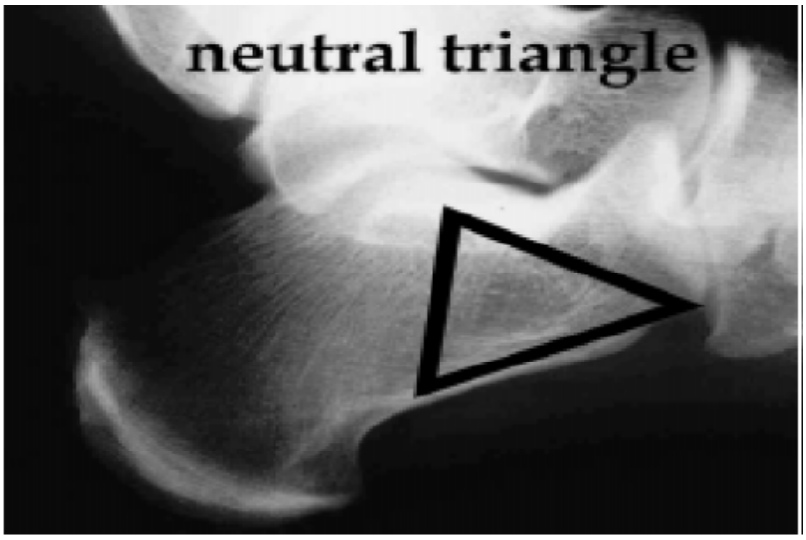



**Fig 10:The Neutral Triangle**

Lateral view of the radiograph of the calcaneum is used to identify two important angles one is bohler angle otherwise called tuber angle of bohler(refer fig 11) usually between 20 to 40 degree, formed by two lines first line starts from the highest point on the anterior process of the calcaneum to highest point on the posterior facet. The second lines tangential to the superior edge of the tuberosity. Decreases in this angle it indicates the weight bearing surface of the calcaneum has collapsed and shifting the body weight anteriorly

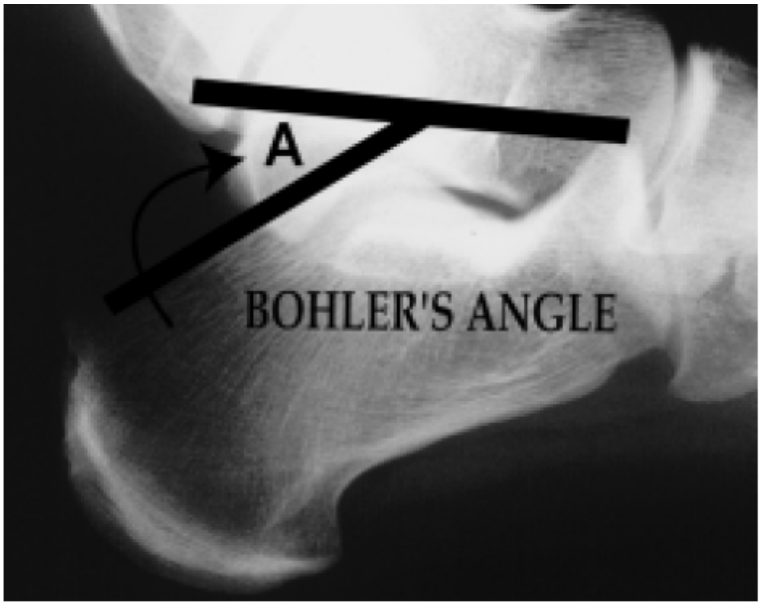



**Fig 11: Bohler's angle.**

Second angle, cruciate angle of gissane (refer fig 12) is seen directly inferior to the lateral process of the talus it is represented by two strong cortical struts that extend laterally and form an obtuse angle. The first strut extend along the lateral border of the posterior facet, the second extends anteriorly to the beak of the calcaneum. Normal gissane angle 90 to 110 degree.

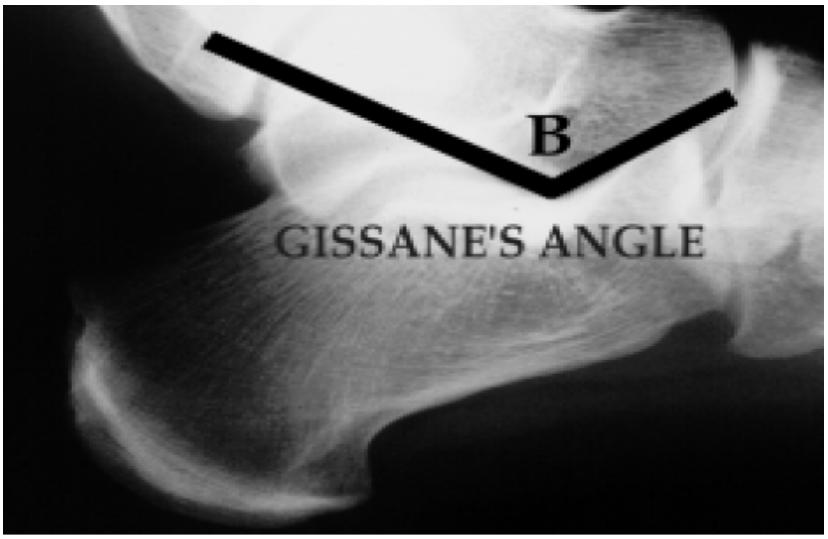



**Fig 12: The Gissane's Angle.**

McLaughln pointed out that reduction or reversal of this angle indicates only the degree of the proximal displacement of the tuberosity and therefore the angle can be decreased in both the extraarticular, intraarticular fractures thus limiting its usefulness.

**RADIOGRAPHIC EVALUATION:**

The initial evaluationof the fracture should be done with plain radiographs.This includes anteroposterior, lateral and Harris axial views.If articular involvement is diagnosed CT scanning should be performed. Many special radiographic views like Mortise view, Broden view and Anthonson's oblique view were described.

The lateral view confirms the diagnosis and classifies fractures according to Essex-Lopresti into joint depression type or tongue type.

The Harris axial view of the heel visualizes the joint surface, loss of height, increase in width and angulation of the tuberosity fragment. Axial view is taken with ankle dorsiflexed by means of a bandage held by the patient and the x-ray tube tilted 45 degrees from the foot withits axis parallel to the posterior compartment of the joint.

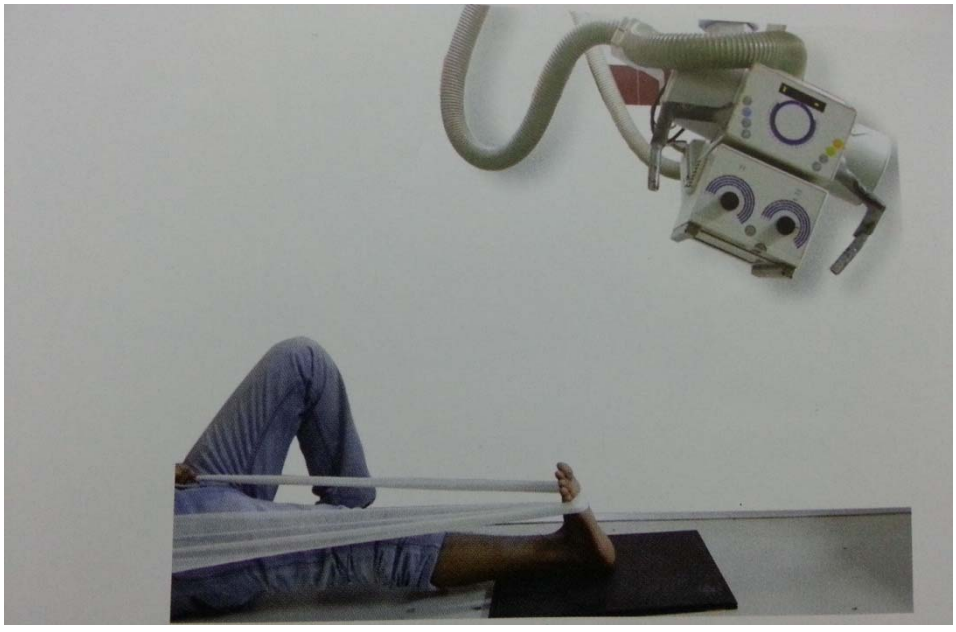


Fig 13 –Axial Harris view


Fig 14 – AXIAL VIEW

Broden's view is a reproducible means of demonstrating the posterior facet on radiographs.It is obtained with foot in neutral position and leg internally rotated 30-40 degrees.The x-ray beam is centered over the lateral malleolus and radiographs made with the tube angled 40,30,20,10 degrees cephalad.The 10 degree view shows the posterior portion of the facet and 40 degrees shows the anterior portion.Intraopertive fluoroscopic visualization of Broden projection is helpful in verifying the reduction of posterior facet.


Fig 16.BRODEN'S VIEW - $10^0$


Fig 17.BRODEN'S VIEW- $20^0$

Fig 18.BRODEN'S VIEW- $40^0$

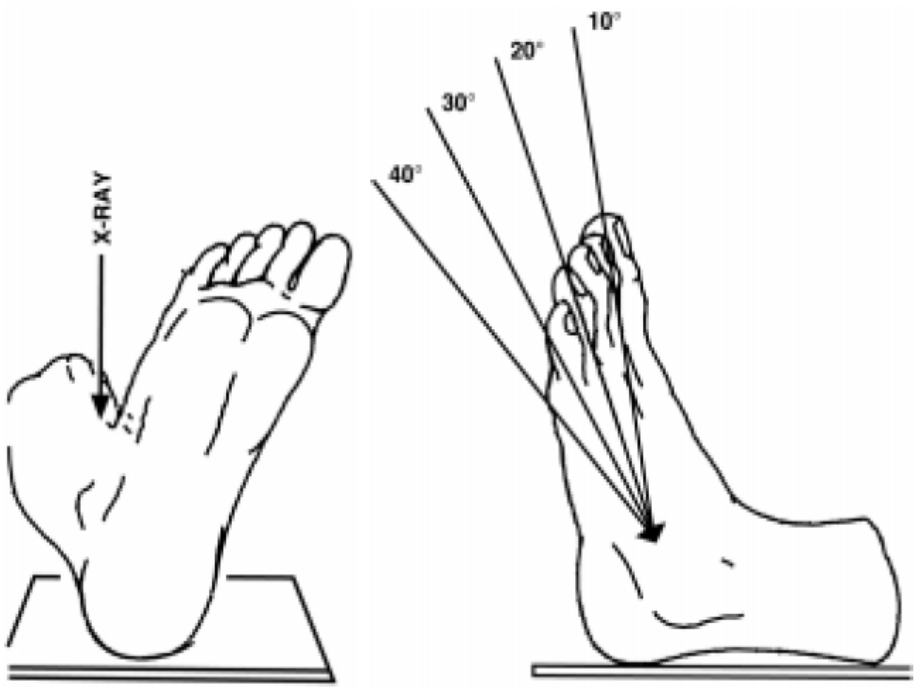



Fig 19: Broden's view

## CT SCAN

CT scanning provides excellent information regarding the number of fractures on the posterior facet and its location. It offers data for diagnosis,classification and treatment.CT images ( Fig 20,21) should be obtained in the axial, 30 degree semicoronal, and saggittal planes with three-dimensional reconstruction.

Axial views gives information about calcaneocuboid joint, the anteroinferior aspect of the posterior facet, and the sustentaculum. Coronal views shows the posterior facet, sustentaculum,shape of the heel overall. Saggittal views shows the posterior facet, the calcaneal tuberosity and the anterior process. Though three dimensional CT scanning is an interesting modality the definition of articular surface is not sufficient for pre-operative planning.

CT evaluation has allowed classification systems to offer prognostic significance. By reducing the need for multiple views of the heel, it reduces the radiation dose and discomfort to the patient.

In our series we have used the anteroposterior, lateral and Harris axial views along with CT imaging for classification and preoperative planning.

Fig 20.CT-INTRAARTICULAR FRACTURE.

Fig 21.COMMUNITTED FRACTURE.

## TREATMENT OPTIONS

## CONSERVATIVE TREATMENT

## SURGICAL MANAGEMENT

## A. CONSERVATIVE TREATMENT

**INDICATIONS:**

1. Undisplaced or minimally displaced extraarticular fractures
2. Undisplaced intraarticular fractures.
3. Anterior process fractures with less than 25% involvement of the calcaneocuboid articulation.
4. Fracture in patients with other comorbid conditions which are prohibiting the surgery.
5. Elderly patients who are household ambulator
6. Chronic smokers, uncontrolled diabetes and peripheral vascular diseases.

The nonoperative treatment consists of initial rest, ice, compression, elevation regime followed by a supportive splint. After the swelling subside the prefabricated fracture boot, with the ankle locked in the neutral flexion to prevent the equinus contracture. Apply the elastic compression stocking to minimise the dependant edema. Early subtalar and ankle joint range of motion exercise are initiated. Weight bearing restriction are maintained for upto 10 to 12 weeks until radiographic union is confirmed. After three months gradual progressing weight bearing is started as tolerated.

## A. SURGICAL MANAGEMENT:

1. Minimally invasive technique
2. Open reduction internal fixation with plate osteosynthesis
3. Ligamentotaxis
4. Primary arthrodesis

## 1. MINIMALLY INVASIVE METHOD

**INDICATION :**

a. Communitted fracture or impending soft tissue compromise

b. Peripheral vascular disease.

c. Heavy smoker

d. Uncontrolled diabetes

**IMPLANT :**

a. K-wire

b. Cancellous screw

**TECHNIQUE**

Small incision over the fracture fragments, reduced by Essex-Lopressti manoeuvre, this manoeuvre entails indirect reduction of the fracture by leveraging with a K-wire/ Steinman pin or a Schantz screw inserted into the posterior tuberosity fragment like a joystick. The manoeuvre has its role in tongue type fractures, particularly , Sander's type IIC, in which this fragments contains the whole posterior facet, displaced in

entirely. However , it can also be used in type IIB as well as more complex fractures, with or without other maneuver.

**ADVANTAGE**

a. Postoperative wound complication is less.

b. Tongue type fractures can be managed.

**DISADVANTAGE**

a. In case of communited fractures, subtalar congruity couldnot be obtained.

**2. PLATE OSTEOSYNTHESIS**

Open reduction internal fixation with plate osteosynthesis is the standard operative treatment for intraarticular calcaneal fractures.

**APPROACH**: Extensile Lateral Approach

Advantage of the approach is excellent exposure of the subtalar joint and anatomical reduction of the fracture fragment under vision.

**IMPLANT** :

A. Nonlocking compression plate with 3.5mm cancellous screw

B. Locking compression plate with locking compression screw

These can also be used :-

a. One third tubular plate

b. Cervical h plate

c. 3.5mm recon plate

d. Recon y plate

e. Tentacle calcaneal plate

**ADVANTAGE**

a. Early mobilization

b. Prevent the post operative collapse

**3. LIGAMENTOTAXIS**

Reduced fracture fragments by FORGON principles of ligamentotaxis.

Skeletal traction over the three bony points( tuberosity of calcaneum, talus and cuboid )

Under fluoroscopy control depress the fracture fragments elevated percutaneously by k wires and fixed with lag screw.

**ADVANTAGE**

a. Re-establishing the calcaneal morphology

b. Talocalcaneal relationship resulting in restoration of ankle and transverse dorsal joint range of motion

**4. PRIMARY ARTHRODESIS**

Only indication is Sander's Type IV fractures

**TECHNIQUE**

Posterior facet is denuded of its cartilage in both the surface after adequate reduction of the calcaneal tuberosity and joint surface, then the graft is placed. The fusion is stabilized by 6.5mm cancellous screw, screw directed from axially through the OsCalcis into talar dome. Upto three months nonweight bearing walking.

## BONE GRAFTS AND SUBSTITUTES

Pioneer of the bone graft in calcaneal fractures **PALMER**.

Graft is being used to fill the defect and maintain the neutral angle with rotation even upto 90 degree relation to the subtalar joint when axial load depress the posterior facet.

120 cases operated by Sander's Et al[17] without grafting not even single case developed in postoperative collapse. Overall the decision to use bone grafts and substitutes based on the

a. Patient status

b. Functional needs

c. Fracture pattern

d. Type of fixation

e. Available materials

## TIME OF SURGERY

The most commonly accepted course is to wait until the swelling resolves and the blisters are reepithelized before proceding with the surgery.

The great deal of swelling of foot and ankle with blistering of skin. Soft tissue damage aggravated by surgery and a difficult postoperative wound closure due to skin edema, so increase the risk of skin necrosis and infection. These are the factors, operative treatment undertaken within three weeks of fracture within early consolidation, if after 3 weeks fracture fragment reduction will be difficult.

Resolve of the swelling is marked by the “ **WRINKLETEST** “ it presents as skin wrinkles over the lateral aspect of foot and ankle with dorsiflexion and eversion.

Fig 22: The Wrinkle Test

## VARIOUS SURGICAL APPROACHES[9]

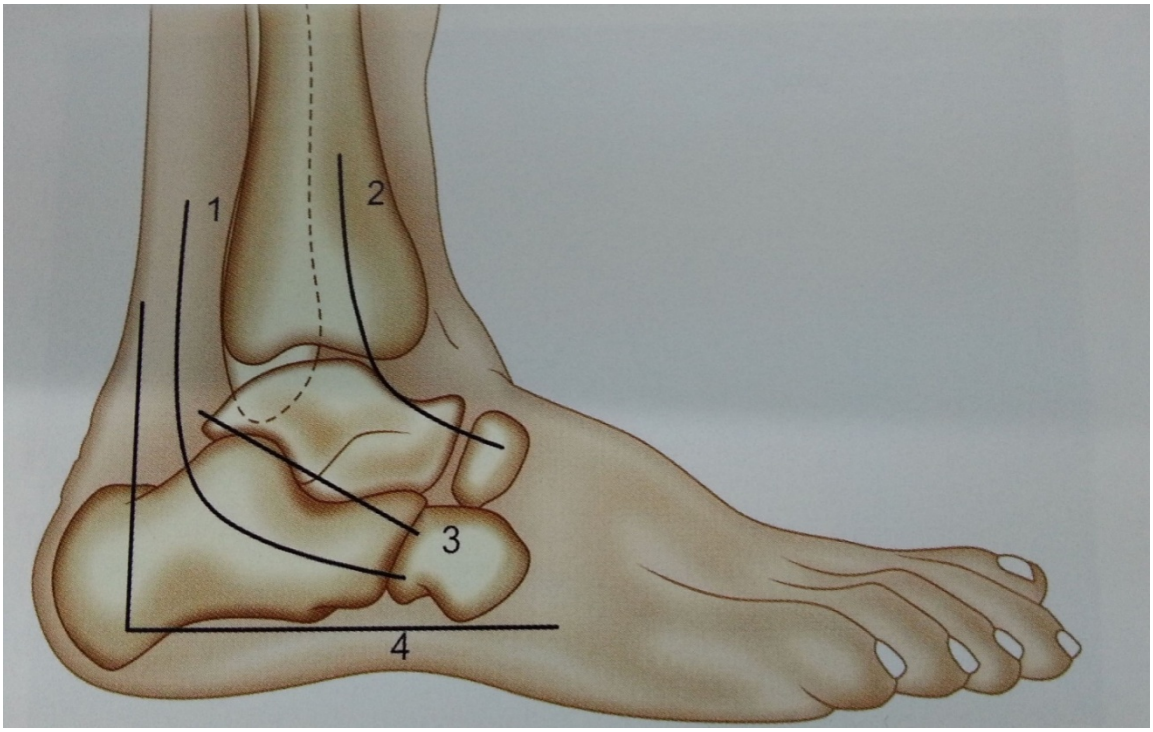



Fig 23 Extensile Lateral approach Vs Sinus Tarsi approach

1- Sural nerve, 2- superficial peroneal nerve, 3- sinus tarsi approach, 4- extensile lateral approach

## CALCANEAL OPERATIVE APPROACHES

1. The Palmer approach
2. Sinus tarsi approach
3. Small lateral approach
4. Extensile sinus tarsi approach
5. Geel and Flemister approach
6. Posterior plantar approach
7. Straight lateral subtalar approach
8. Extended lateral transcalcaneal approach
9. Sustentatcular approach
10. Medial approach
11. Carr’s modification of medial approach
12. Gallie ‘s approach
13. Cincinatti University approach
14. Combined medial and lateral approach
15. Ollier approach

## EXTENSILE LATERAL APPROACH

Described by **FERNANDEZ**

Standard approach for surgical fixation of displaced intraarticular calcaneal fractures.

It provides excellent exposure to subtalar joint, anterior process, lateral wall and calcaneal tuberosity. Adequate visualisation of these structures facilitates the anatomic reduction of articular surface and the restoration of normal calcaneal morphology.

These are the primary goal of surgical treatment

## LOCKING COMPRESSION PLATE

With the advent of locking plate concept by Wagner and A.O group, the concept was extended for use in foot and ankle. The plate is applied through the lateral extensile approach and fragment screw provide bicortical and (or) unicortical fixation. The threaded locking holes offer a fixed angle construct to buttress the articular surfaces of the calacaneum and permit multiple points of fixation to buttress small fragments. The locking holes provide 15 degree of angulation when using 2.7 mm cortical screws and 5 degree of angulation when using 3.5 mm cortical system. This locking calcaneal plate is side specific, made of titanium and comes in two sizes of 69mm and 76mm variation of this concept have been marketed by different implant manufactures. The calcaneal locking plate seems to fulfil all the requisites desired in calcaneal fracture fixation. It has specific proven

advantages with better hold in bone, lower profile, versatility in screw placement, avoiding or minimizing the need for graft or bone substitutes and allowing for earlier weight bearing. This is evidenced by the study of Race et al[19].

## COMPLICATIONS

Divided into early complications and late complications

## EARLY COMPLICATIONS

1. Primary healing with superficial wound infection
2. Deep wound complication with osteomyelitis
3. Compartment syndrome
4. Sural nerve injury
5. Implant related

## LATE COMPLICATIONS

1. Arthritis
2. Malunion
3. Nonunion
4. Nonreduction in tuberosity
5. Heel exostosis
6. Reflex sympathetic dystrophy

## WOUND INFECTION

Superficial wound infection is the most common complication. Treated with conservatively using saline dressing and oral antibiotic.

In cases of deep infection repeated wound debridement is tried and free tissue transfer is attempted if needed. Implant removal in case of diffuse osteomyelitis is present.

**SURAL NERVE INJURY**

Operative treatment associated with nerve injury mostly with sural nerve presents with neuroma or loss of sensation in the affected region. But in extensile lateral approach this would be avoided.

**COMPARTMENT SYNDROME**

The literature document an incident 1-17% of patients who develop compartment syndrome following calcaneal fracture.But Indian literature does not report cases of compartment syndrome after calcaneal fractures [9].

**ARTHRITIS**

Subtalar arthritis is the most common form of arthritis seen in calcaneal fractures. Calcaneocuboid joint arthritis can also occur in calcaneal fractures.

It was diagnosed by intrarticular injection of local anaesthetics which relieves the pain.

Treatment conservative measures like footwear modification, NSAIDs, walking aids. If these measures are not relieving the pain, subtalar arthrodesis is next line of management.

## MALREDUCON OF TUBEROSITY

Malposition can occur in both locking compression plate and nonlocking compression plate resulting in varus angulation of hindfoot. When the patient stands on toes the fibular fragment become more pronounced and the treatment consists of lateral shoe wedges or corrective osteotomy.

## HEEL EXOSTOSIS

Plantar aspect of the heel develop painful bony prominence due to fracture healing. Treatment consist of the use of heel pads or operative removal. In 1921 COTTON first described the operative management of heel exostosis by avoiding a plantar incision[7].

## REFLEX SYMPATHETIC DYSTROPHY (COMPLEX REGIONAL PAIN SYNDROME)

There is two types **CRPS Type I** – not limited to the single peripheral nerve distribution, but associated with edema, changes in the skin blood flow.

**CRPSType II** – more commonly associated with open surgery or open injury in lateral side affecting sural nerve[9]. In case of medial side injuries tibial nerve is affected. Diagnosis is based mainly on clinical examination.

Treatment – physiotherapy, analgesics, antidepressant, sympathetic blockade.

## CALCANEAL MALUNION

In 1921, **COTTON** identified calcaneal malunion in heel. This malunion would produce lateral wall abutment, peroneal impingement and heel malalignment[7]. In case of heel malalignment extraarticular osteotomy is done giving good results.

## CLASSIFICATION OF CALCANEAL MALUNION ( STEPHEN'S AND SANDER'S CLASSIFICATION)[9]

**TypeI** – Large lateral wall exostosis with or without marginal subtalar arthrosis.

**TypeII** – Lateral wall exostosis combined with subtalar arthritis involving the whole of subtalar joint.

**TypeIII**- Type II + Malpositioned heel either in varus or valgus.

| | |
|---|---|
| **TYPE I** | **PERONEAL TENOLYSIS, LATERAL EXOSTECTOMY** |
| **TYPE II** | **TENOLYSIS, EXOSTECTOMY,SUBTALAR ARTHRODESIS** |
| **TYPE III** | **ABOVE MEASURES WITH ADDITIONAL OSTEOTOMY OF THE CALCANEAL BODY.** |

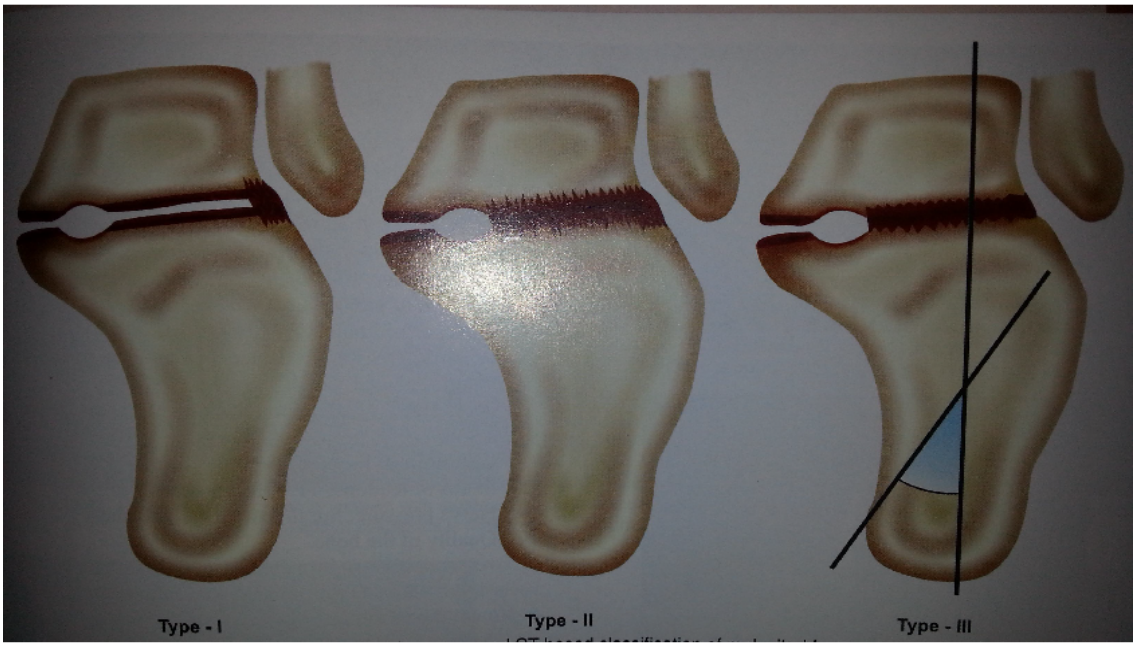





**Fig 24: Stephens and Sanders classification of calcaneal Malunion**

# MATERIALS AND METHODS

In our institution 20 patients with 23 fractures with displaced intra-articular calcaneal fractures were selected for this prospective study. The study period is from July 2012 to July 2014. Out of these patients 3 patients had bilateral intra-articular calcaneal fractures. 17 fractures occurred in men and 3 fractures occurred in women.

10 patients were treated with Locking Compression Plate and 10 patients were treated with non-locking compression plate based on our inclusion and exclusion criteria .Only sanders II, III, and IV part fractures were included in the study.

**MODE OF INJURY**:

Fall from height : 11

Road traffic accidents : 9

**ASSOCIATED INJURIES**:

Out of 20 patients 5 patients had associated injuries, 3 patients had spine injuries without neurological defecit.one patient had Intertrochontric fracture another patient had subtrochantric fracture.

The locking compression plate group had 3 cases associated with other injuries. one case a fracture subtrochanter Seinsheimer's classification type IIB for whom Proximal Femoral Nail was performed and 2 cases of

spine fractures one being a D12 anterior wedge compression fracture and other L2 wedge compression fracture,both patients without neurological defecit.

The NonLocking Compression plate group had 2 associated injuries. Of these 1 patient had spine injuries (L1Anterior Wedge Compression fracture) without neurological deficit. One patient had intertrochanteric fracture treated with Dyanamic Hip Screw.

No other systemic injuries were associated with these fractures.

**INCLUSION CRITERIA:**

1. Age group between 20-60 years
2. Non diabetic or under strict glycemic control.
3. Sander's type II-IV.
4. Closed fractures, compound fracture grade I.
5. Dislocated calcaneal fracture ( posterior articular facet stepoff>2mm, significant shortening, loss of height, widening of calcaneum ( decrease the Bohler's angle and increase the Gissane angle, valgus deviation >10 degree , varus deviation >5degree. )
6. Presenting within 3 weeks of injury.
7. If associated with other fractures.

**EXCLUSION CRITERIA:**

1.Age <20- >60 years.

2. Severe uncontrolled diabetis mellitus/severe medical problems/severe soft tissue injury.

3. Sander's type I

4. Grade II & III compound fracture

5. Associated vertebral fracture with neurological deficit.

6. Non-reducible dislocation of the calcaneum which needs subtalar arthrodesis.

7. >21 days of injury.

**AGE AND SEX DISTRIBUTION:**

10 patients were operated with Locking Compression Plate of which 9 were male and one female. The Non-locking compression plate group which consists of 8 patients, out of these 2 fractures occurred in female.

**PRE-OPERATIVE ASSESSMENT:**

All patients were evaluated using the Computerised Tomography (CT) method and classified using SANDERS classification.

X-RAYS:

1.Standard ANTEROPOSTERIOR AND LATERAL VIEWS

AXIAL VIEW{HARRIS VIEW}

CT : Axial and coronal views

ANTIEDEMA MEASURES like :-

- Elevation of Limb
- Posterior Plaster splint
- Antibiotics
- Anti-inflammatory drugs
- Daily dressing in cases of abrasion.

**IMPLANTS REQUIRED:**

1. Calcaneal Locking compression Plate with locking compression screw ( 4mm cancellous locking compression screw )

2. Calcaneal nonlocking compression plate with 3.5mm cancellous screw.

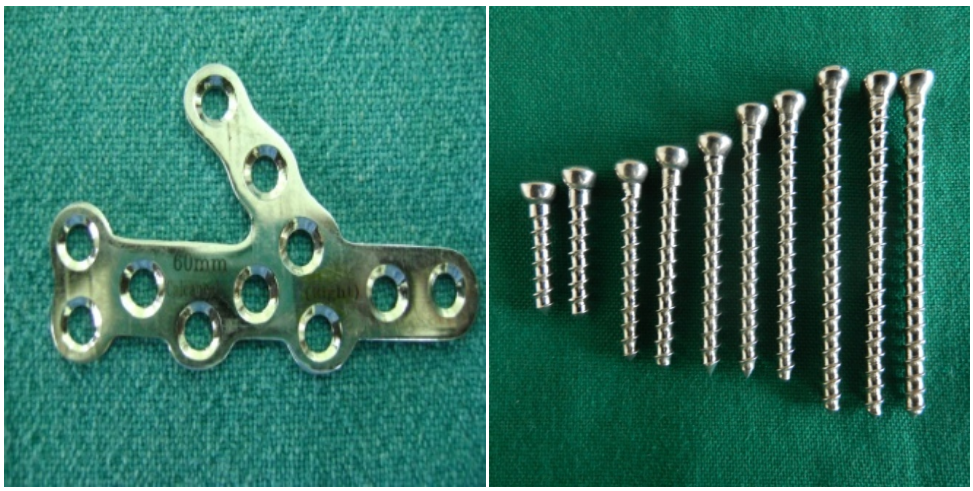


**Fig 25a: Non-locking plates and 3.5mm cancellous screws.**

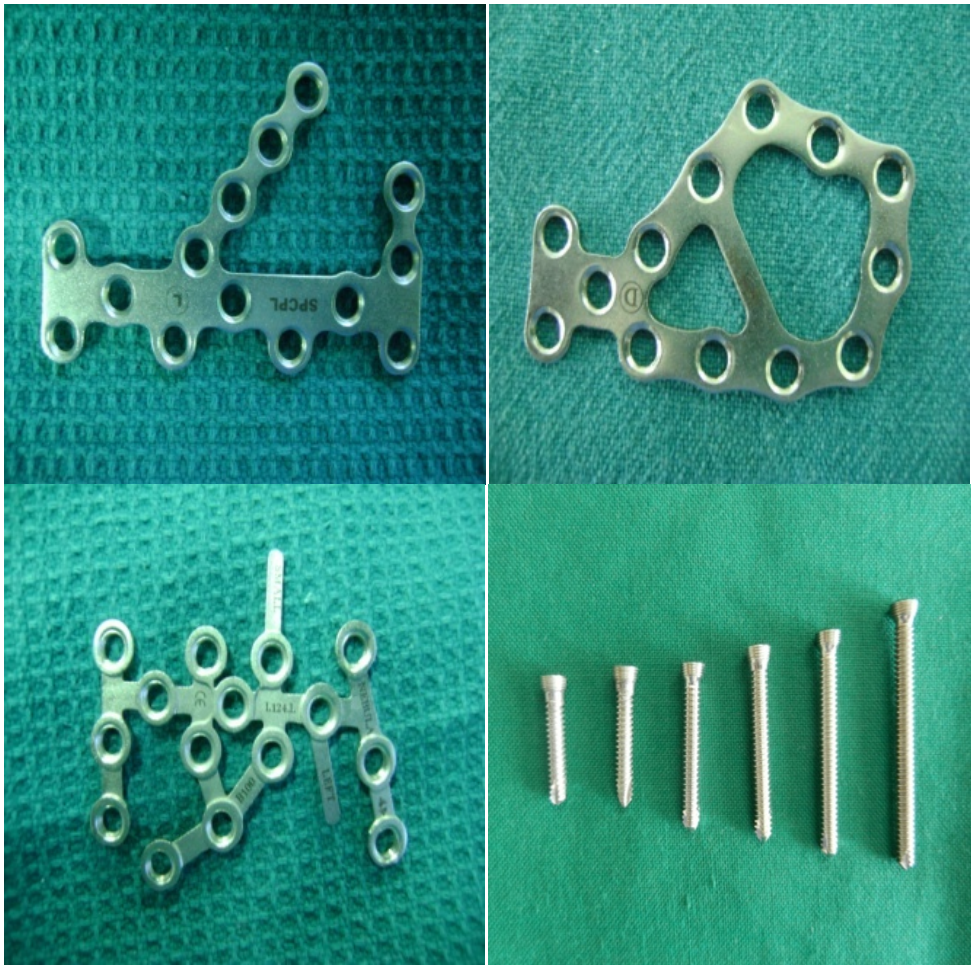


**Fig 25b: Locking plates and screws**

**BONE GRAFT SUBSTITUTES**:

G Bone

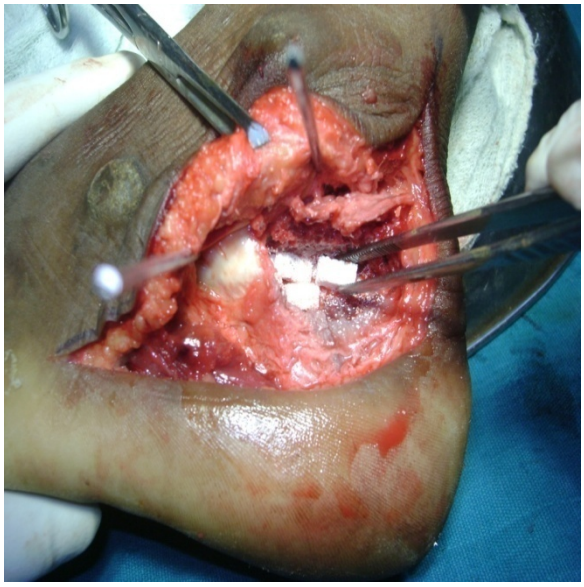


Fig26: Filling the void with ‘G bone’.

Synthetic granules are of synthetic calcium hydroxyappatite in low crystalline form. It is a mixture of hydroxyappatite, tricalcium phosphate and other form of calcium such as calcium carbonate and bicalcium phosphate. The body absorbs it fast.

G-bone derived from bovine bone which has been sintered at a very high temperature of $+500^{0}$C. It does not carry any risk of transmission of diseases.

**TIMING OF SURGERY**:

All patients were operated within three weeks of injury, ranging from 10-19 days from the time of fracture, if the soft tissue condition was satisfactory. The mean duration was 14 days. In one patient, calcaneum was

operated 7 days later, after the fixation of intertrochanteric fracture. In another case subtrochanteric fracture was operated, PFN placed and after 6 days calcaneal fracture was treated.

**ANAESTHESIA AND POSITION**:

Surgery was done in standard radiolucent table with patient in lateral position . Spinal anaesthesia was used in all patients. Image intensifier was placed opposite to the surgical site for free movement. Pneumatic tourniquet inflated to 300 mm of Hg was used in all patients to minimize blood loss and to achieve a clear operative field for visualization of subtalar joint and accurate reduction of posterior facet.

**SURGICAL TECHNIQUE**:

An extensile lateral approach was used in all patients. The land marks are lateral malleolus, calcaneocuboid joint and base of fifth metatarsal. Incision made in a right angled fashion with the vertical limb started 4 cm above the lateral malleolus between fibula and tendoachilles and extended downwards till the skin colour between the lateral ankle and sole changed. The angle of incision should be obtuse to prevent skin necrosis. The horizontal limb is extended distally up to the calcaneo cuboid joint.(fig 27&28).

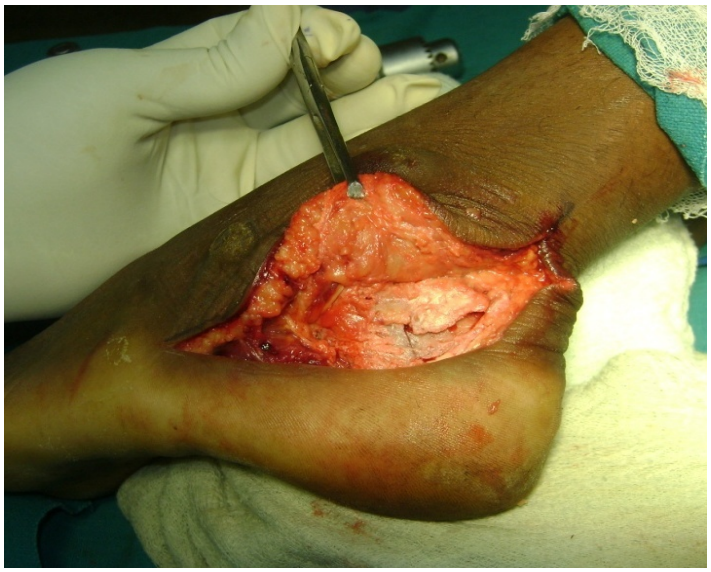


Fig 27 &28: Skin incision using extensile lateral approach.

The wound is then dissected deep onto the periosteum. Once the bone is reached over the lateral wall of the calcaneum, a full thickness flap is thus raised along with the periosteum by sharp dissection until subtalar joint is exposed.

The  sural nerve lies approximately 1.5cm anterior to the insertion of Achilles tendon is cautiously retracted and raised along with the flap.

It crosses the line of incision at its proximal and distal part. Retractors should be avoided as it tears the skin from subcutaneous layer, which leads to postoperative skin necrosis.

The flap is retracted by means of two or three k wires placed either over talus, lateral malleolus and cuboid until the subtalar joint and calcaneocuboid is visualized (fig29). The peroneal tendons are dissected from the peroneal tubercle and subluxated over the lateral malleolus and held with k wire over lateral malleolus.

Fig 29: Retraction by k wires

**REDUCTION TECHNIQUE:**

The lateral wall of the calcaneum is elevated with a curved osteotome. The depressed posterior facet lies within the neutral triangle .The articular fragment is elevated by a small periosteal elevator or by an osteotome (fig 30 & 31).

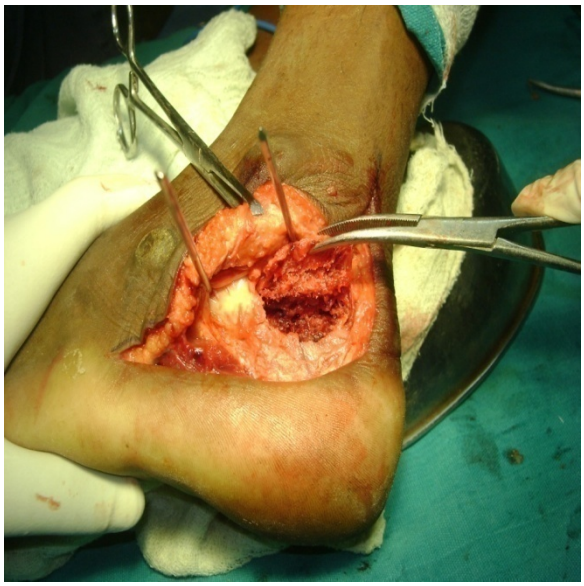
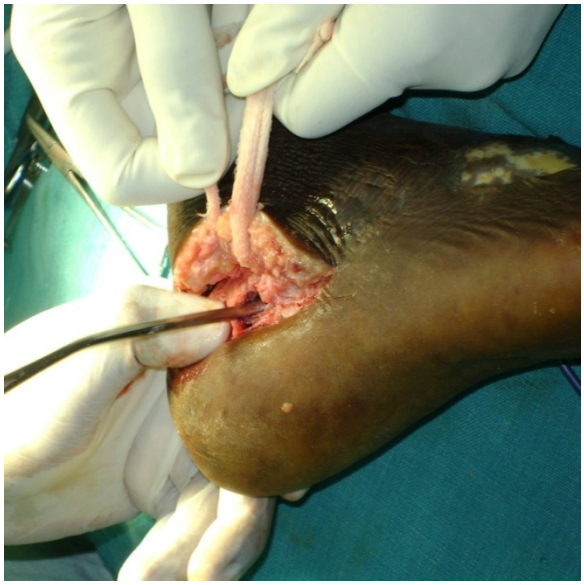


**Fig30&31: lateral wall opened by a curved osteotome.**



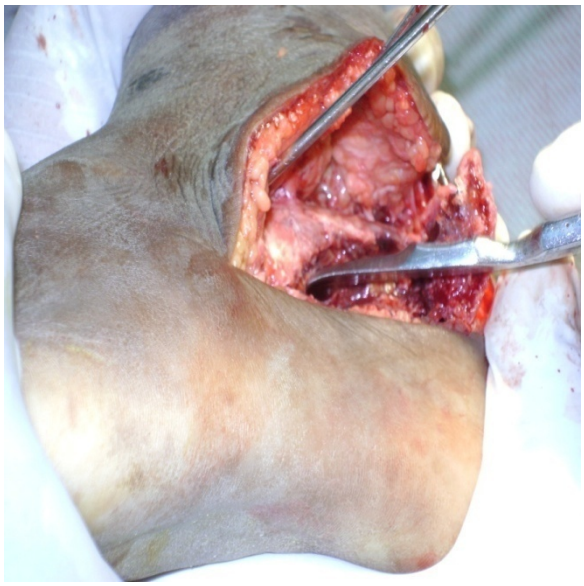


**Fig 32 & 33: Reduction maneuver**

At this stage reduction of the tuberosity is done if in varus angulation. A schanz screw or a 3 mm k wire is passed from the posteroinferior corner of the calcaneal tuberosity. Reduction can be aided by a periosteal elevators or osteotome placed through the void beneath the articular surface and the tuberosity is pulled plantarward and distracted medially. This corrects the

varus angulation and provisionally fixed with axially directed 2.5mm k wires

The posterior facet reduction is done under direct vision. In cases with severe crush injuries the articular surface may be rotated to 90-180 degrees and lies within the void in the neutral triangle, we elevated the fragment using cervical spine inter-body spreader gently and held in position by means of k wires (fig35). Intra-operative radiographic assessment of Bohler's and Gissane's angle is done.

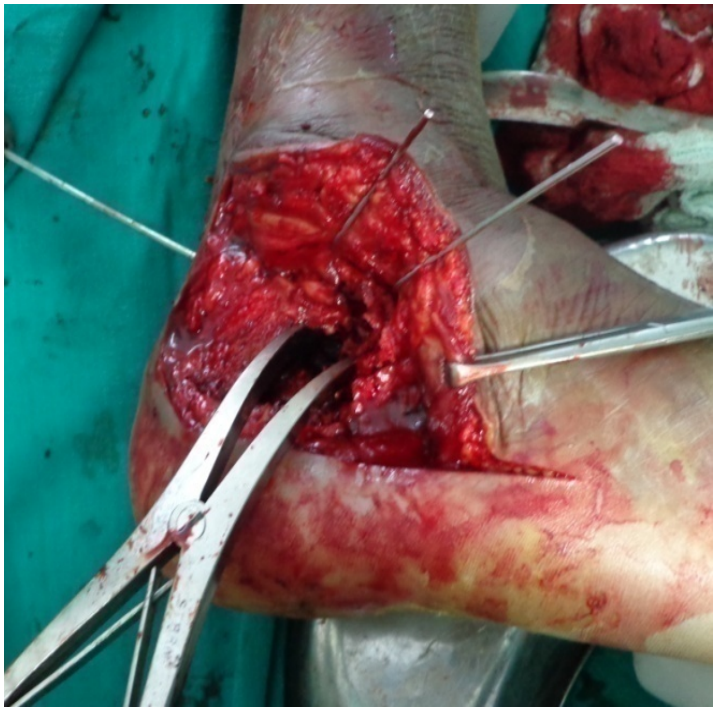


**Fig 35: Reduction of posterior facet using cervical spine inter-body spreader**

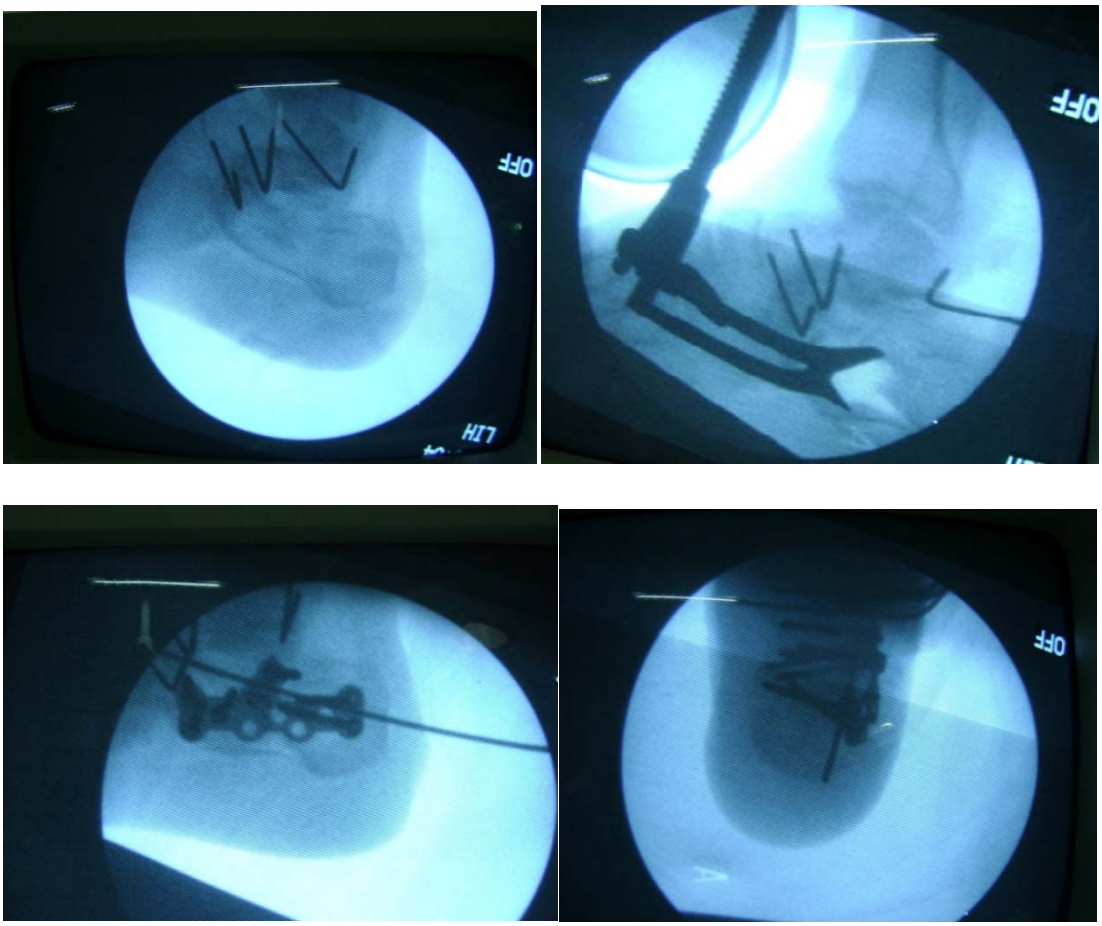


**Fig 36: Intra-operative images**

The reduction of posterior facet results is a large void which is filled with bone graft or bone graft substitutes and impacted. Graft impaction prevents postoperative collapse of the posterior facet.

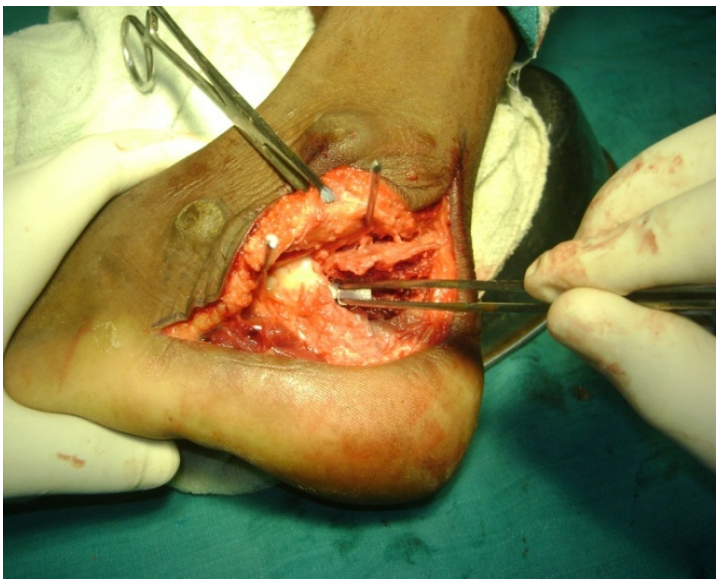


**Fig37&38: Defect filled with autograft or G bone.**

The lateral wall remnant is then placed and the low profile calcaneal plate is plate is positioned. The plate is secured by 4mm cancellous screws

over the anterior process, posterior tuberosity and the thalamic portion which lies beneath the facet.

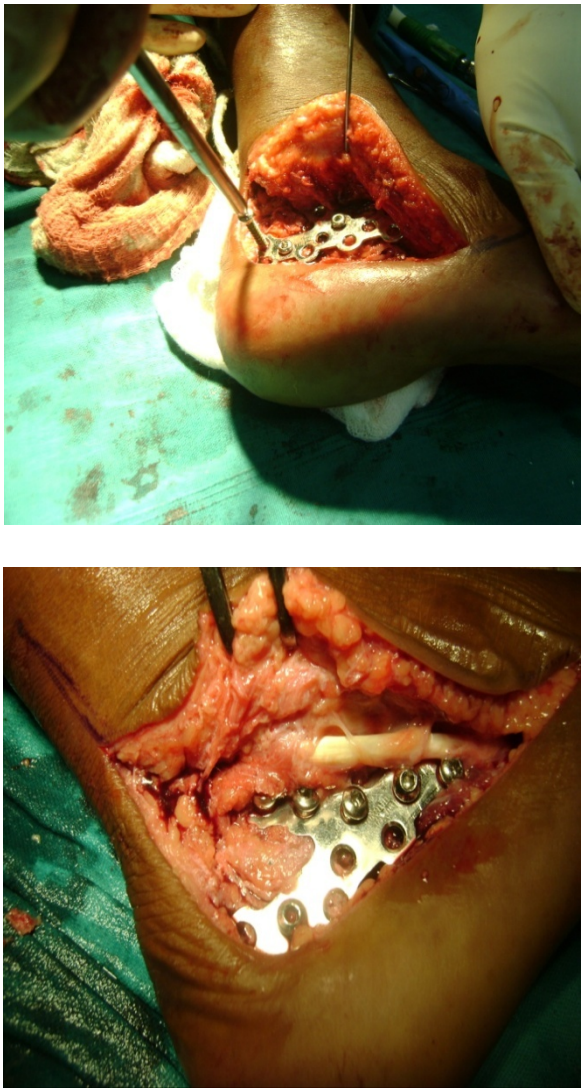


**Fig 39&40: Fixation with calcaneal plate.**

Bending of the plate is not done as the plate is low profile; it contours with placement of screws. We used suction drain in all cases passing through the tip of the vertical limb. The flap is sutured using ‘0’ vicryl from the apex to proximal and distal ends and temporarily clamped and tied in uniform tension. The skin is sutured with ‘3’o silk. A compression bandage is applied

and tourniquet released. The limb is immobilized in a posterior plaster splint in 90 degrees.

**FIG41&42: wound closure**

**POSTOPERATIVE PROTOCOL**:

All patients were immobilized with below knee posterior plaster splint and limb elevated. Drain is removed after 48 hrs and first EOT done on 3rd or 4th day under sterile conditions. We maintained operated foot in below knee slab until suture removal which is done at 18th to 21st postoperative days. Patients with serous discharges or signs of skin necrosis had a dressing change at 9th or 10th day and further dressings as per skin conditions. Range of motion exercise were started in patients with satisfactory wound, after suture removal.

In case of non-locking compression plate, all patients were kept on posterior plaster splint with non-weight bearing until 10 weeks and partial weight bearing upto 30% body weight is allowed until 12 weeks. Full weight bearing is allowed after 12 weeks.

In case of locking compression plate this will be two weeks earlier. In bilateral calcaneal fractures two weeks later.

**Fig 43: After suture removal.**

## FOLLOW UP PROTOCOL

All patients were regularly followed up once a month for three months, after that three months interval followup was maintained. At discharge, end of 3 months,6 month and after one year following x-rays were taken; standard anteroposterior, lateral, and axial views.

In all the patients following radiological parameters were assessed:-

- Bohler's angle
- Gissan's angle
- Calcaneal height
- Calcaneal width

Functional evaluation was done us AOFAS-Ankle Hind Foot scale. All operated cases were followed for minimum period of one year.

1 YEAR FOLLOWUP( Fig 44)

Fig 44

# RESULTS

Our study includes 20 patients with 23 fractures.10 patients[GROUP A] were operated with Locking Compression plate osteosynthesis and 10 patients[GROUP B] underwent non-locking compression plate treatment. The mean age group of all patients in locking compression plate group was 31.3years (21-40 }and in the non-locking compression plate group was 29.4 years (21-50). The age group 31-40 dominates the series accounting for 60% among LCP and 40% of non-locking compression cases.

Bilateral fractures accounts for 3 patients (15%) were operated LCP. Left calcaneum constitutes 40% and right calcaneum constitutes 60% in the remaining patients.

Calcaneal fractures caused by fall from height includes 11 fractures (55%) and by Road Traffic Accident includes 9 fractures (45%) overall. In the LCP group 6 fractures (60%) are caused by fall from height and 4 fractures (40%) by RTA. In the non-LCP group 5 fractures (50%) are caused by fall from height and 5 fractures (50%) by RTA. .

Among the fractures , LCP group sanders II was 3 fractures (30%), type III was 3 fractures (30%) and type IV was 4 fractures (40%) . The NLCP group has sanders type II in 5 fractures (50%), type III in 4 fractures (40%) and type IV in one fractures (10%). Sanders type IV dominated in the LCP group and type II in the NLCP group.

The average time from injury to surgery was 14(range 10-19) days. An Extensile lateral approach is used in all patients.All patients were grafted

with autogenous graft in 4 patients(20%) and G-bone in 16cases(80%) fracture union achieved in all patients.

The mean preoperative Bohler's angle is 12.3(8-16 degrees) whereas the mean postoperative Bohler;s angle at the time of discharge 28.6degree ,one year follow up is 28.2(24-32 degrees). Preoperative Gissane's angle averages 133.4(128-141 degrees) and postoperative Gissane's angle at the time of diccharge 118.6degree,one year followup averages 119.88 degrees (116-124 degrees). The Bohler's angle and Gissane's angle was maintained and there was insignificant postoperative collapse of the angles after LCP group.

The non-LCP group had a mean Bohler's angle of 14.7 degrees (10-18 degrees) which had a decrease during the follow up period.At the time of discharge28.3degree,one year followup 20.7degree and the Gissane's angle is 131.2(128-136 degrees),at the time of discharge 117.3degree and mean during follow up is 126.6 (120-136 degrees).There was a followup period decrease in the Bohler's angle and a increase in the Gissane's angle in the non LCP group.

In our study,at end of one year radiological parameters which includes the Bohlers angle, Gissane angle among the LCP group when compared with non-LCP group is statistically significant. Even though calcaneal height and width better in LCP group compared to Non-LCP group but statistically insignificant.

Fracture union was achieved in all patients (100%). At the end of one year followup both LCP and NLCP had decrease in calcaneal height and width when compared to at the time of discharge.But this measures NLCP group compared to LCP group was statistically insignificant.

The mean range of movements at the end of one year includes dorsiflexion 17.94 degrees, plantarflexion 25.8degrees which is 72%and74.2% of normal among the LCP group and dorsiflexion of 16.88 degrees and plantar flexion 24.6degrees which corresponds to 70% and 74% of the normal among the non-LCP group.

The average subtalar range of movements is inversion 12.4 degrees and eversion 9.4 degrees in the operated foot and inversion of 11.2 degrees and eversion of 9.1 degrees in the non LCP foot.

The AOFAS – Ankle Hindfoot Score at the end of one year is excellent in 4 cases(40%),good in 3 cases(30%),fair in 1 cases(10%) and poor in 2 cases(20%) among the LCP group whereas among the non-LCP group excellent score in two patient (20%),good in 2 patients(20%),fair in 2 patients(20%) and poor in 4 patients(40%).

The individual fracture patterns, based on Sander's classification.LCP group is better than non operative group with respect to AOFAS- ANKLE HINDFOOT SCORE, when compared is **statistically insignificant**.

The average score is 82.70% among the patients who underwent LCP and 73.46% among the patients treated operatively.

# STATISTICAL ANALYSIS

## TABLE: 1

## DISTRIBUTION OF AGE BETWEEN LCP AND NLCP GROUP

| S.NO | AGE(IN YEARS) | LCP (N=10) | | NON LCP(N=10) | |
|---|---|---|---|---|---|
| | | N | % | N | % |
| 1. | BELOW 30 | 3 | 30 | 6 | 60 |
| 2. | 31- 40 | 6 | 60 | 4 | 40 |
| 3. | 41AND ABOVE | 1 | 10 | 0 | - |
| | TOTAL | 10 | 100 | 10 | 100 |

From the above table it is very clear that majority of the LCP group cases [60%] belongs to the age group of 31-40 years. Similarly majority of the non-LCP [60%] also belongs to the age group of below 30 years.

**TABLE: 2**

**DISTRIBUTION OF FRACTURES BASED ON SANDERS CLASSIFICATION**

| S.NO | SANDERS | LCP | | NON LCP | | TOTAL | |
|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % |
| 1. | TYPE II | 3 | 30 | 5 | 50 | 8 | 40 |
| 2. | TYPE III | 3 | 30 | 4 | 40 | 7 | 35 |
| 3. | TYPE IV | 4 | 40 | 1 | 10 | 5 | 25 |
| | TOTAL | 10 | 100 | 15 | 10 | 20 | 100 |

Among the fractures LCP group sanders II was 3 fractures (30%), type III was 3 fractures (30%) and type IV was 4 fractures (40%). The NLCP group has sanders type II in 5 fractures (50%), type III in 4 fractures (40%) and type IV in 1 fractures (40%). Sanders type IV dominated in the LCP group and type II in the NLCP group.

**TABLE: 3**

**COMPARISON OF AOFAS – ANKLE HINDFOOT SCORE**

| S.NO | ANKLE HINDFOOT SCORE | LCP | | NON OPERATIVE | | STATISTICS |
|---|---|---|---|---|---|---|
| | | N | % | N | % | |
| 1. | EXCELLENT | 4 | 40 | 2 | 20 | |
| 2. | GOOD | 3 | 30 | 2 | 20 | CHI-SQUARE |
| 3. | FAIR | 1 | 10 | 2 | 20 | 1.867 |
| 4. | POOR | 2 | 20 | 4 | 40 | |

The AOFAS - Ankle Hind Foot Score at the end of one year is excellent in 4 cases(40%),good in 3 cases(30%),fair in 1 case(10%) and poor in 2 cases(20%) among the LCP group whereas among the non-LCP group excellent score in 2 patients (20%),good in 2 patients(20%),fair in 2 patients(20%) and poor in 4 patients(40%).The difference between the LCP and NonLCP cases with respect to AOFAS Hind Foot Score is **statistically not significant.** since the ‘t’ (1.867)value and is insignificant at P value> 0.05 level.

**TABLE: 4**

**TABLE SHOWING COMPARISION OF AOFAS-ANKLE HIND FOOT SCORE BETWEEN LCP AND NLCP CASES**.

| S.NO | VARIABLE | LCP (N=10) | | NON LCP (N=10) | | 't' VALUE |
|---|---|---|---|---|---|---|
| | | mean | SD | mean | SD | |
| 1. | AOFAS- ANKLE HINDFOOT SCORE | 82.53 | 14.88 | 73.47 | 17.18 | 1.599 |

The above table shows comparison between LCP and non-LCP group by 't' test which shows that it is **statistically insignificant.**

**TABLE: 5**

**COMPARISION OF AOFAS-ANKLE HIND FOOT SCORE BASED ON INDIVIDUAL FRACTURE PATTERNS.**

| S. NO | SANDERS | VARIABLES | N | MEAN | SD | 't' VALUE | 'p'VALUE |
|---|---|---|---|---|---|---|---|
| 1 | TYPE II | LCP | 3 | 80.6667 | 61.60 | 1.372* **Not Significant** | 0.219 |
| | | NONLCP | 5 | 61.60 | 22.70 | | |
| 2. | TYPE III | LCP | 6 | 64.33 | 22.50 | 0.557 **Not Significant** | 0.602 |
| | | NON LCP | 6 | 57.25 | 11.18 | | |
| 3. | TYPE IV | LCP | 7 | 62.00 | 21.10 | 1.017 **Not Significant** | 0.384 |
| | | NON LCP | 1 | 38.00 | 24.698 | | |

**P**.<0.05

The individual fracture patterns,based on Sander's classification.LCP group is better than Non- LCP group with respect to AOFAS- ANKLE HINDFOOT SCORE, when compared is **statistically insignificant**(P>0.05)

## TABLE:6

## RADIOLOGICAL PARAMETERS AT ONE YEAR

| ASSESSED ANGLE | GROUP A (LCP) Mean | GROUP B (NLCP) Mean |
|---|---|---|
| **BOHLER'S ANGLE** | | |
| Before operative surgery | 12.3 | 14.7 |
| After operative surgery | 28.6 | 28.3 |
| 3 months | 28.5 | 28.0 |
| 6 months | 28.3 | 24.2 |
| 1 year | 28.2 | 20.7 |
| **GISSANE'S ANGLE** | | |
| Before operative surgery | 133.4 | 131.2 |
| After operative surgery | 118.6 | 117.3 |
| 3 months | 118.4 | 119.6 |
| 6 months | 118.4 | 121.4 |
| 1 year | 119.8 | 126.6 |
| **CALCANEAL HEIGHT** | | |
| Before operative surgery | 41.7 | 42.0 |
| After operative surgery | 47.3 | 47.12 |
| 3 months | 47.1 | 46.5 |

| | | |
|---|---|---|
| 6 months | 47.1 | 46.2 |
| 1 year | 47.0 | 46.2 |
| **CALCANEAL WIDTH** | | |
| Before operative surgery | 55.4 | 55.1 |
| After operative surgery | 49.1 | 49.3 |
| 3 months | 49.3 | 49.7 |
| 6 months | 49.3 | 50.1 |
| 1 year | 49.7 | 50.9 |

## TABLE 7

## TABLE SHOWING COMPARISON OF RADIOLOGICAL PARAMETERS

| S.NO | VARIABLES | | N | SD | 't' VALUE | 'p' VALUE |
|---|---|---|---|---|---|---|
| 1. | FOLLOW UP BOHLER | LCP | 10 | 3.33 | 8.452* | .000* |
| | | NON LCP | 10 | 1.69 | | |
| 2. | FOLLOW UP GISSANE | LCP | 10 | 4.477 | 3.977* | .001* |
| | | NON LCP | 10 | 5.581 | | |
| 3. | FOLLOW UP HEIGHT | LCP | 10 | 1.716 | .115 | .909 |
| | | NON LCP | 10 | 2.097 | | |
| 4. | FOLLOW UP WIDTH | LCP | 10 | 2.945 | 1.092 | 0.289 |
| | | NON LCP | 10 | 3.190 | | |

In our series the radiological parameters which includes the Bohler's angle, Gissane's angle among the LCP group when compared with the non-LCP group is **statistically significant** P<0.05. Even though calcaneal height and width better in LCP group compared to NLCP group with respect to AOFAS – Ankle Hindfoot score, stastically insignificant at p value <0 .05.

## TABLE-8

## COMPARISSION OF VARIOUS STUDY

| | Our Study | RAK, V, IRA D, et al | ZEMAN P, et al |
|---|---|---|---|
| Design | Prospective, Randamized | Retrospective | Retrospective |
| Total no of patient | 20 | 76 | 30 |
| Study period | 2012 – 14 | 2004 – 07 | 2005 – 07 |
| Time of surgery (days) | 14 | 81 | 12 |
| Approach (Extensile Lateral) | Yes | Yes | Yes |
| Bongraft or bone substitutes | 100% | 82% Non locking<br>10% Locking | 40% |
| Superficial skin infection<br>LCP<br>Non LCP | <br>10%<br>20% | <br>3%<br>17% | <br>21%<br>--- |
| Deep infection<br>LCP<br>Non LCP | <br>--<br>10% | <br>--<br>12% | <br>--<br>-- |
| Radiological parameters | LCP better maintained than Non LCP | LCP better than Non LCP | Better LCP |
| AOFAS-ANKLE HIND FOOTSCORE | LCP better than Non LCP | LCP better than Non LCP | Better LCP |

**TABLE 9**

**EARLY COMPLICATIONS**

| Complications | LCP | Non – LCP |
|---|---|---|
| Superficial Skin Infections | 1 | 2 |
| Deep infections (Osteomyelitis) | 0 | 1 |
| Implant Removal | 0 | 1 |

**TABLE 10**

**LATE COMPLICATION**

| Complications | LCP | Non – LCP |
|---|---|---|
| Subtalar Arthritis | 0 | 2 |
| Impingement | 0 | 1 |

## COMPLICATIONS

The LCP group had complications in 0ne patients accounting for 10% due to superficial infection which was treated conservatively.

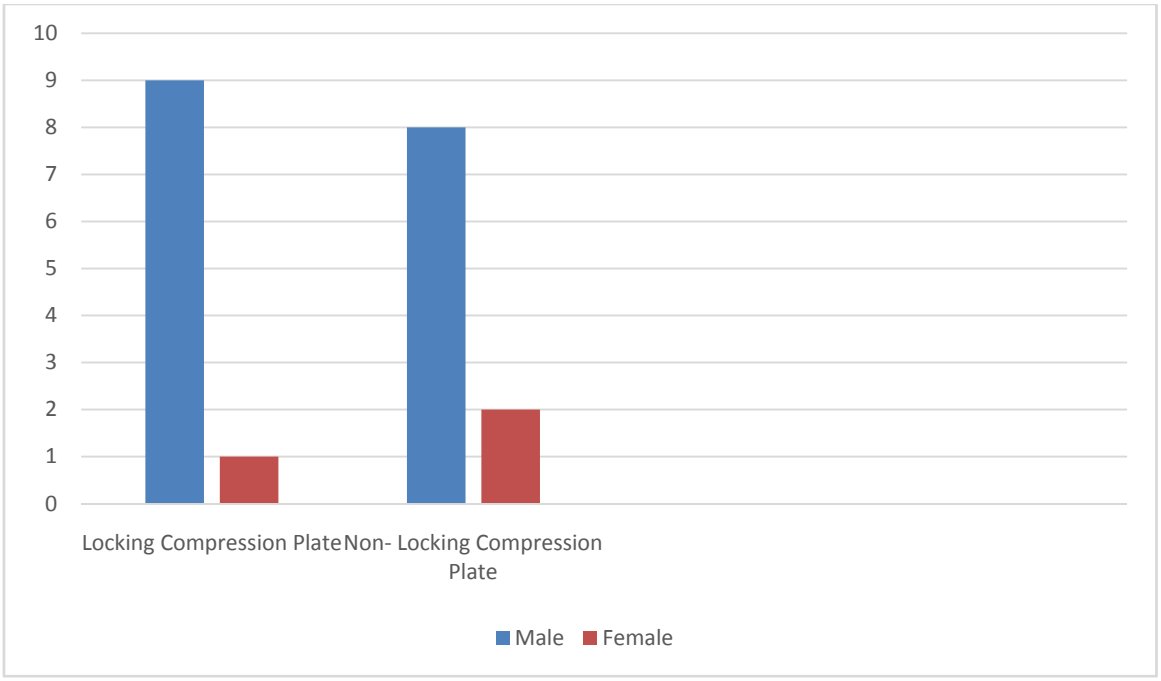
The non-LCP group had complications in 3 fractures (30%). Two cases had superficial skin infection which was treated conservatively. One patient had deep infection which was treated i.v antibiotics, it was not controlled. Later osteomyelitis was developed and implant was removed at the end of $4^{th}$ month. In one year followup two patients had subtalar arthritic

changes present in the followup X-ray. One patient had heel pad pain, impingement treated by analgesics and foot wear change.

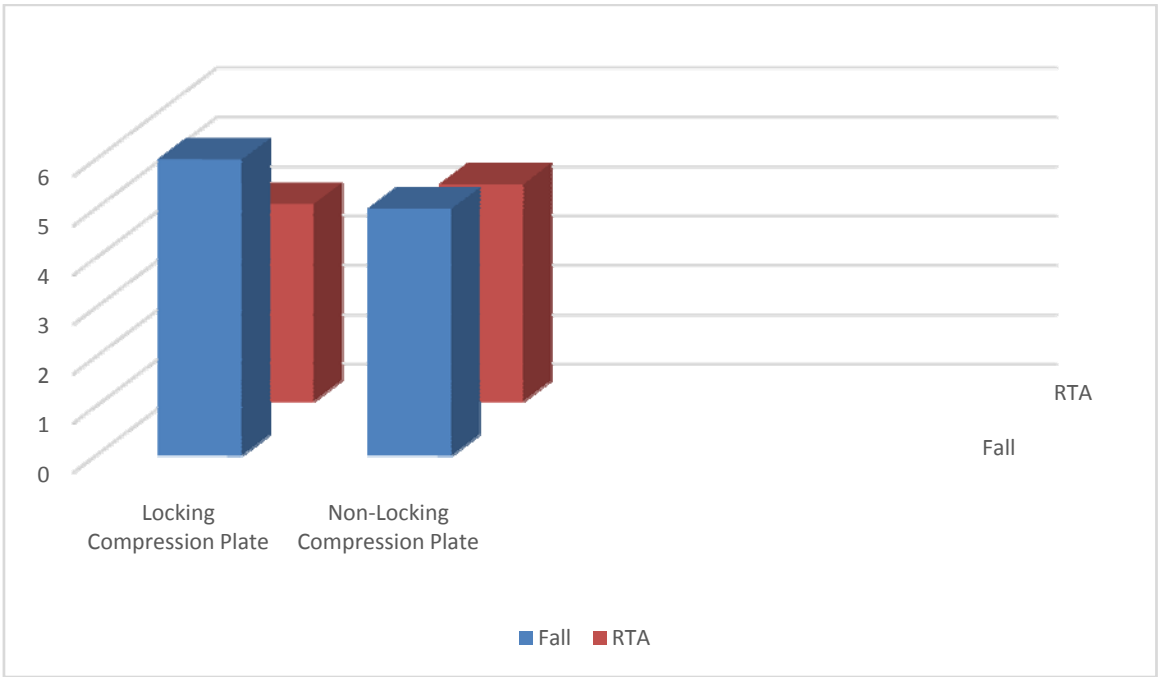
**Fig 45: Skin Necrosis**

**Fig 46: Plate Exposed raw area.**

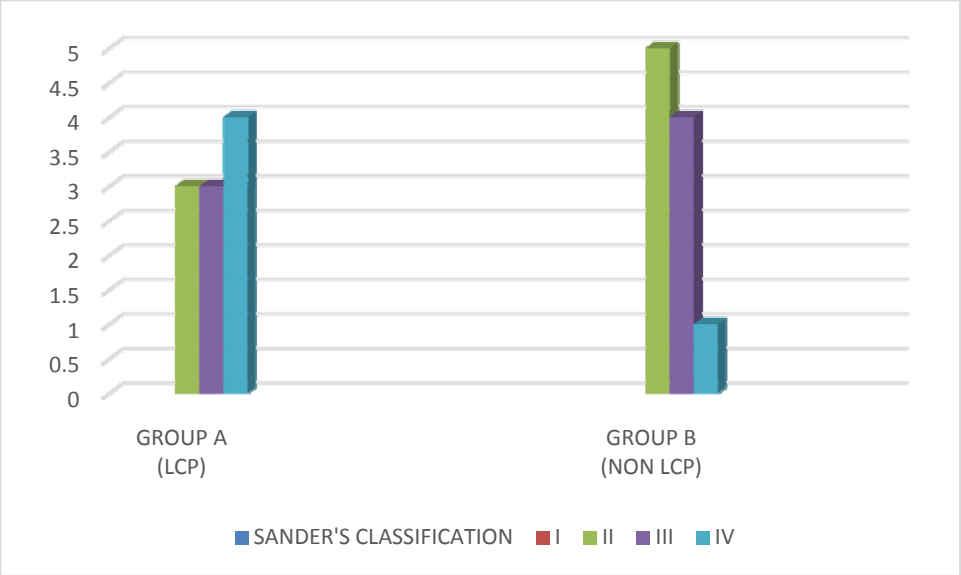
## SEX RATIO




## MODE OF INJURY

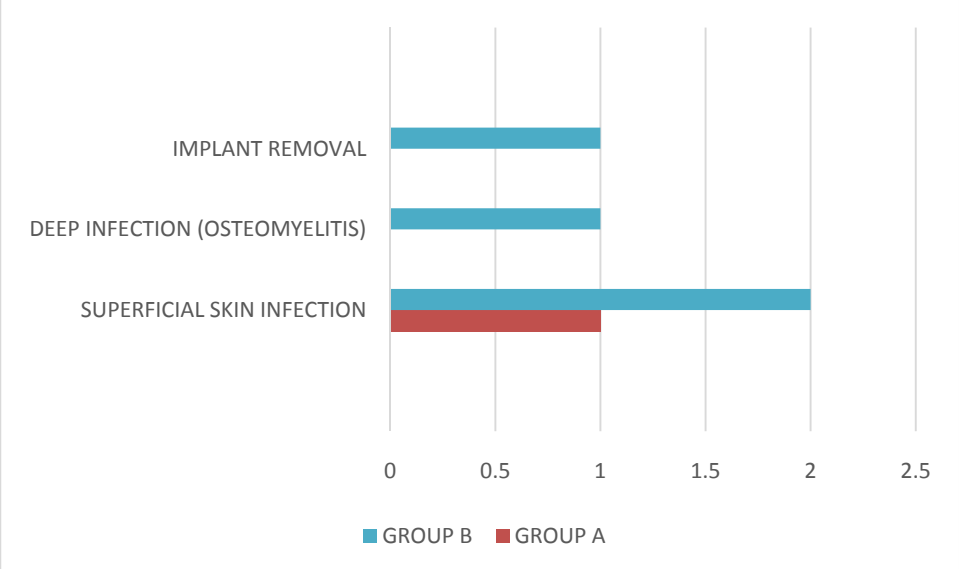


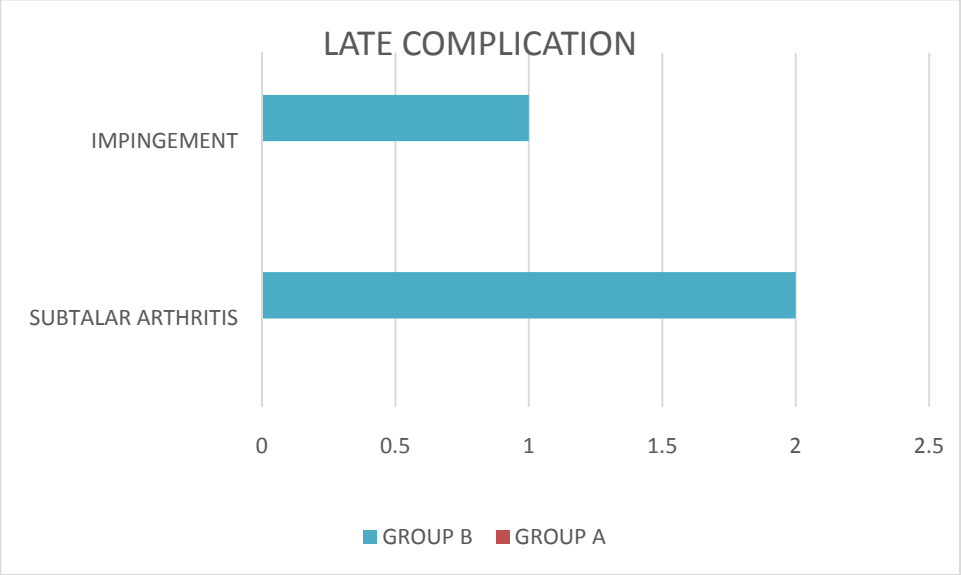
## FRACTURES BASED ON SANDER'S CLASSIFICATION

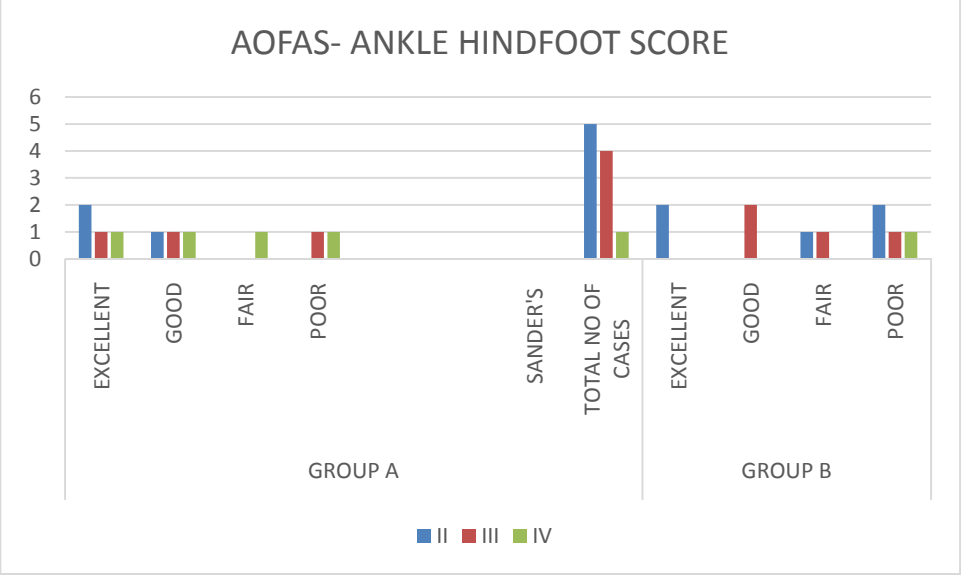


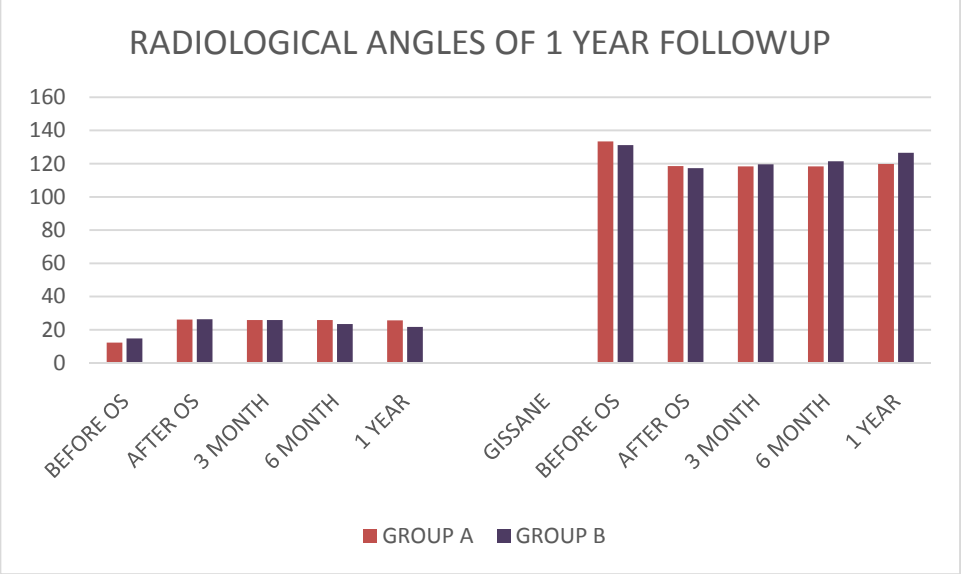

## COMPLICATIONS

## EARLY COMPLICATION



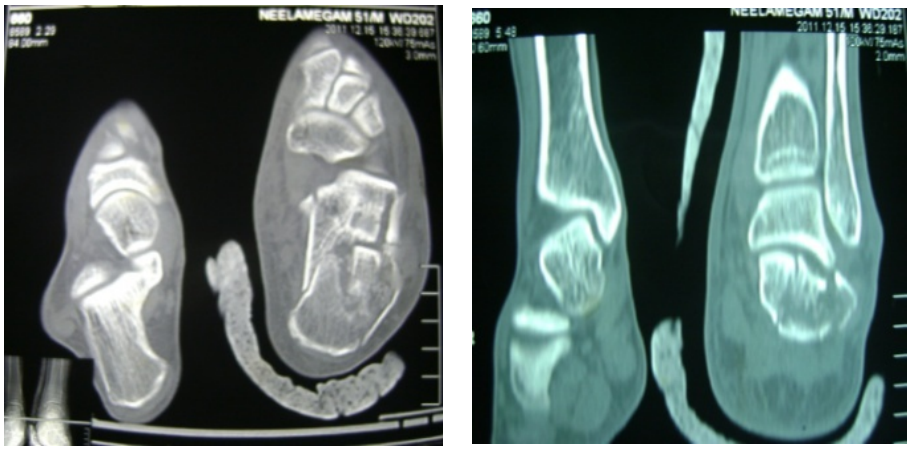

LATE COMPLICATION
IMPINGEMENT
SUBTALAR ARTHRITIS
0
0.5
1
1.5
2
2.5
GROUP B
GROUP A


AOFAS- ANKLE HINDFOOT SCORE
6
5
4
3
2
1
0
EXCELLENT
GOOD
FAIR
POOR
SANDER'S
TOTAL NO OF CASES
EXCELLENT
GOOD
FAIR
POOR
GROUP A
GROUP B
II
III
IV


RADIOLOGICAL ANGLES OF 1 YEAR FOLLOWUP
160
140
120
100
80
60
40
20
0
BEFORE OS
AFTER OS
3 MONTH
6 MONTH
1 YEAR
GISSANE
BEFORE OS
AFTER OS
3 MONTH
6 MONTH
1 YEAR
GROUP A
GROUP B

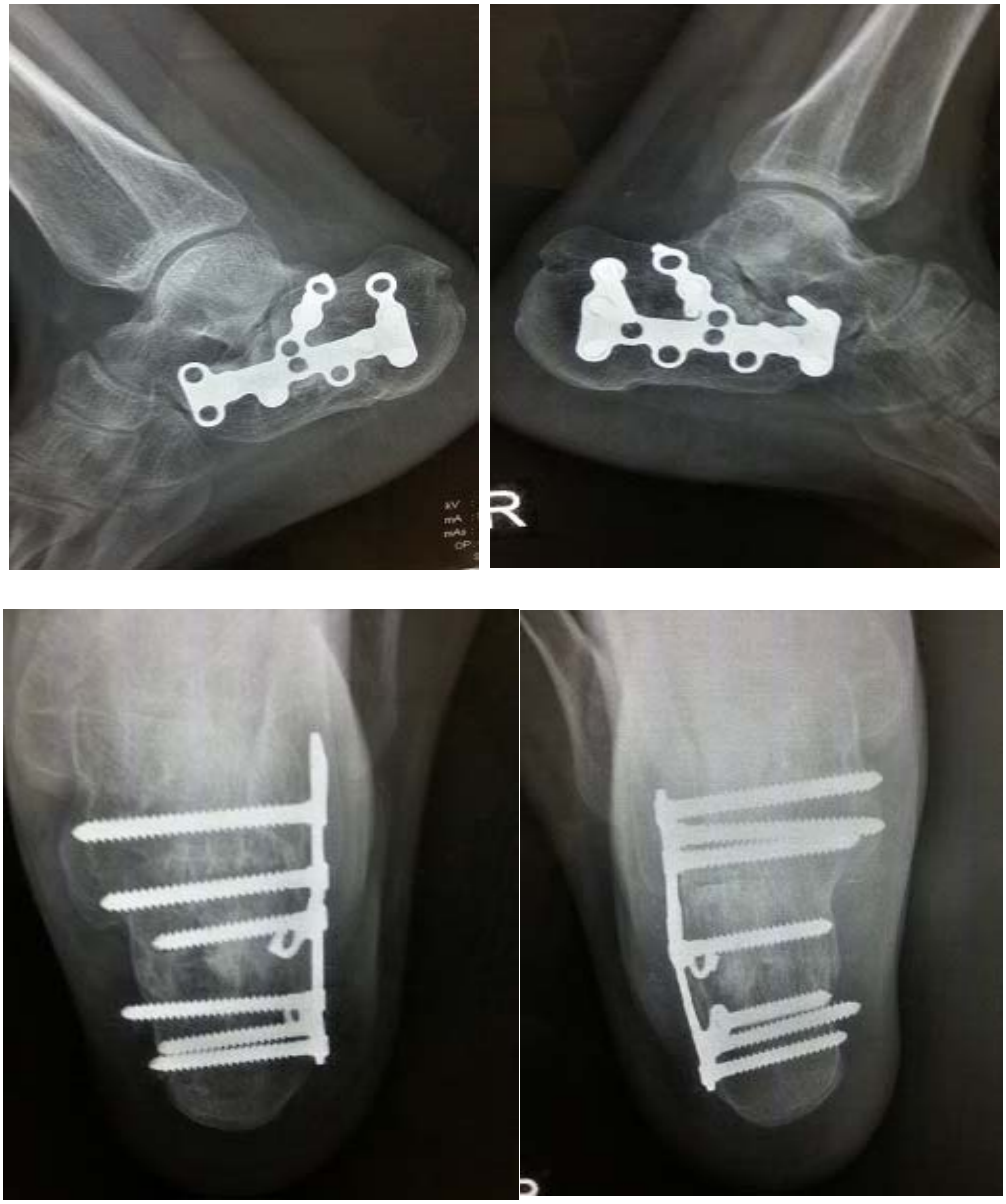
# OPERATIVE CASES WITH LCP -1

## PRE OP-XRAY/CT



## INTRA OPERATIVE

# POST OPERATIVE X-RAYS

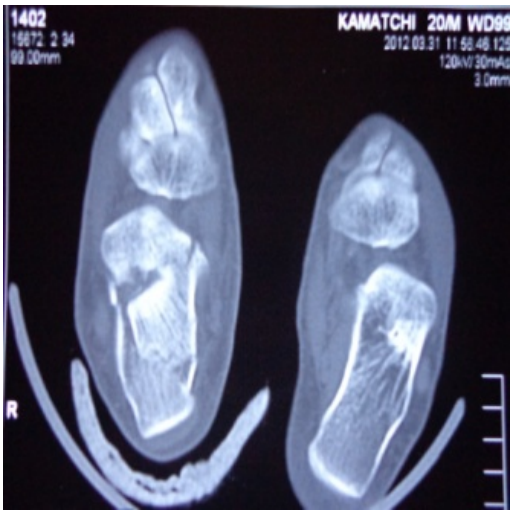


## AT THE TIME OF SUTURE REMOVAL

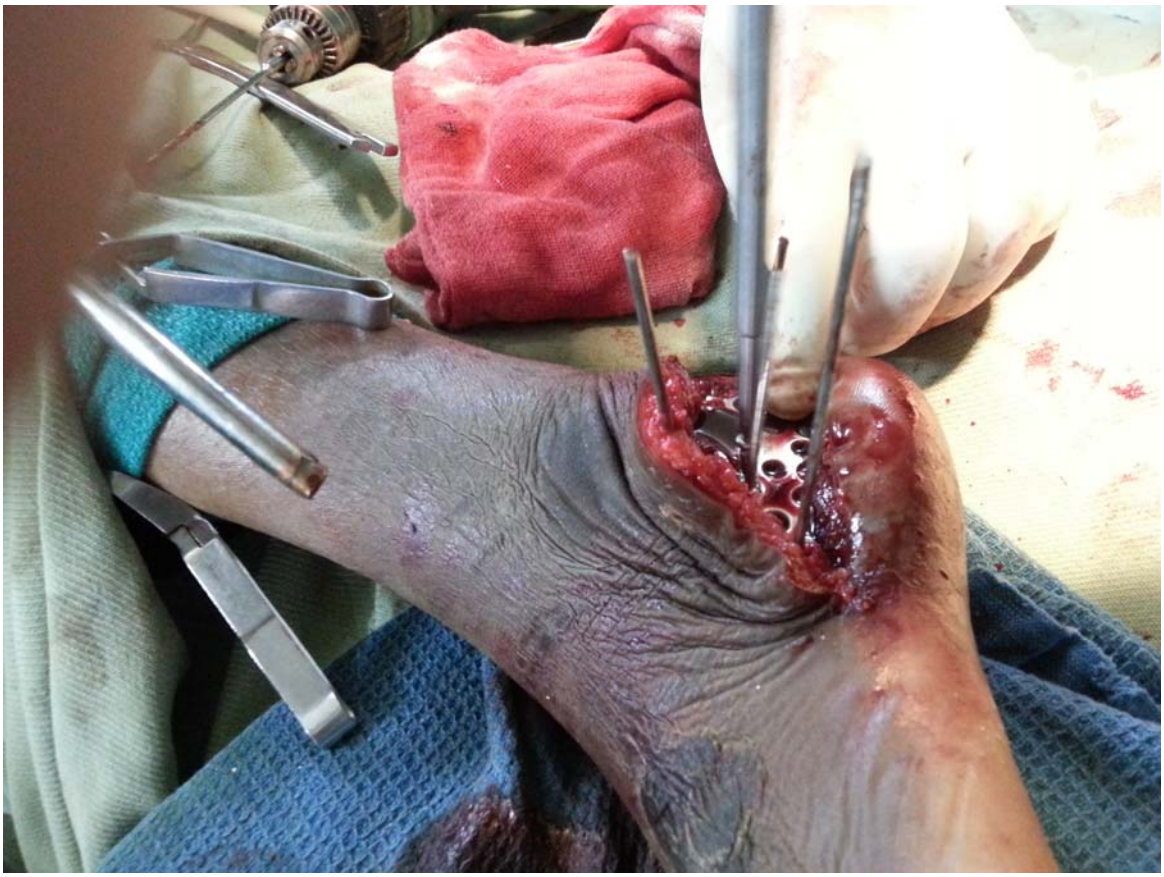
# MOVEMENTS

# OPERATIVE CASES FOR LCP -2

## PRE-OP



## *INTRAOPERATIVE*



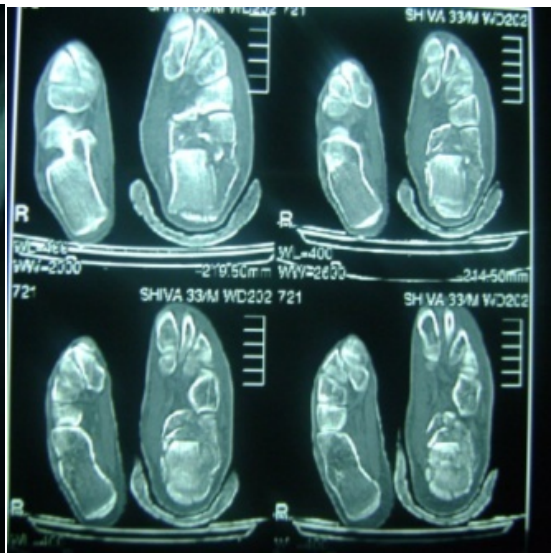
## AFTER 1 YEAR

## MOVEMENTS

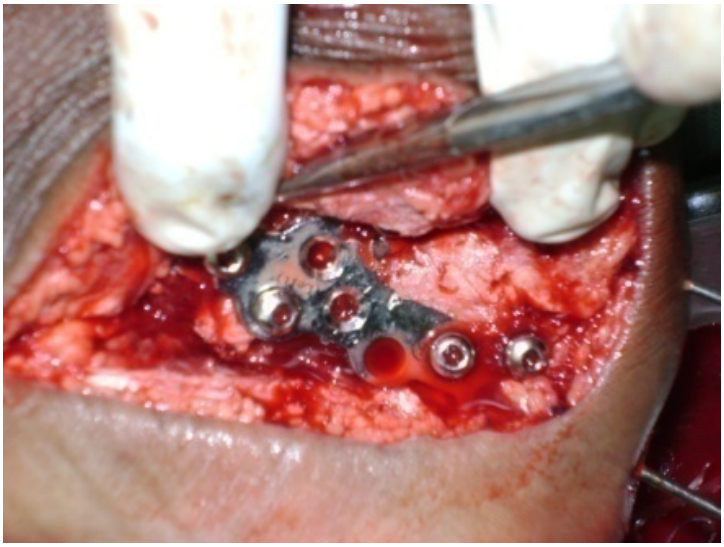
# OPERATIVE CASES FOR LCP- 3

## PRE-OP





## INTRA-OP



## POST-OP X-RAYS

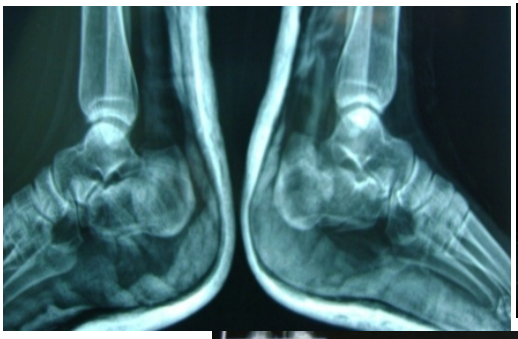

## AT 1 YEAR FOLLOWUP

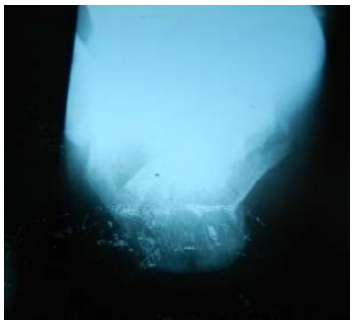
# MOVEMENTS AND MEASUREMENTS

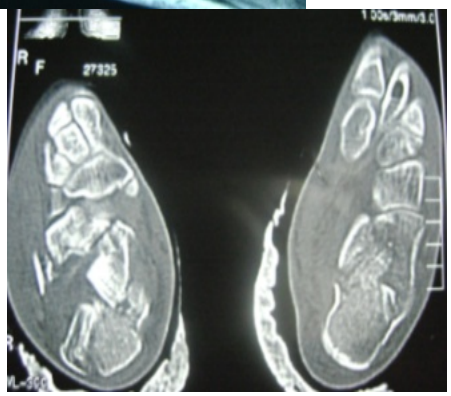



## OPERATIVE CASES FOR NLCP - 1

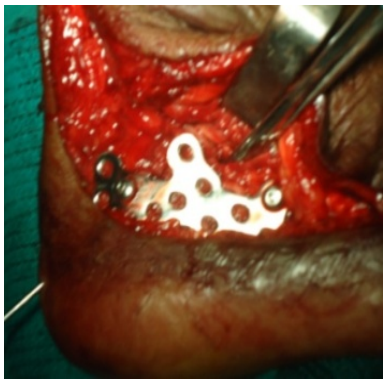
### PRE-OP








### INTRA-OP



### POST-OP


## AT 6 MONTHS

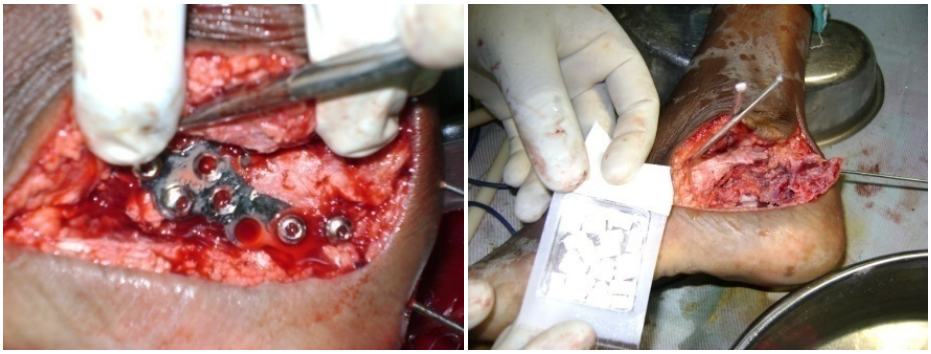
## AT 1 YEAR

# MOVEMENTS

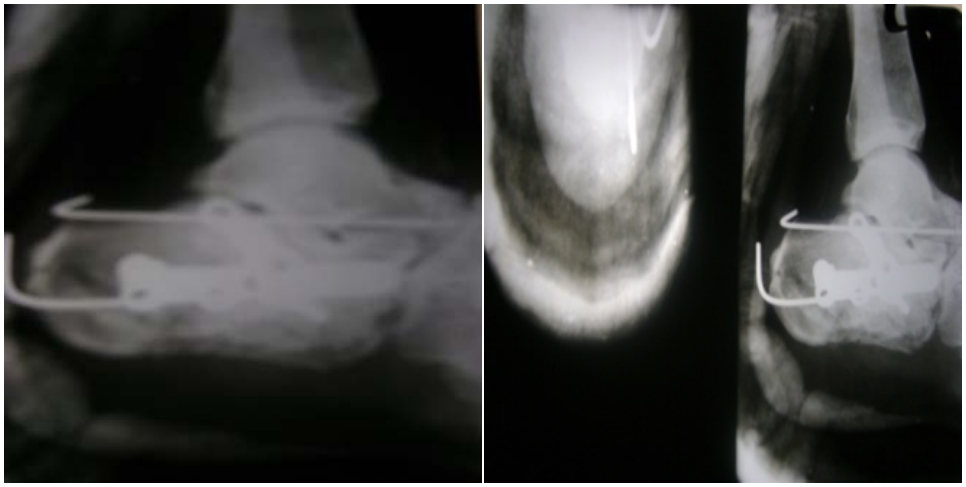
# OPERATIVE CASE FOR NLCP- 2

## PRE-OP CT & X-RAY

## INTRAOPERATIVE



## POST-OP



## AFTER 1 YEAR


## ARTHRODESIS

## AFTER 18 MONTHS

# MOVEMENTS

# DISCUSSION

In the last decade open reduction and internal plate fixation of intraarticular calcaneal fractures has become a standard surgical method with low complication rate and better quality of life after the surgery[1-25].

Our study group were treated with locking compression plate with locking compression screw and non locking compression plate with 3.5mm cancellous screw. 80% of the patient were treated with bone graft substitute ‘G’ bone 20% patient treated with autograft. Autograft patient had another scar incision and chances for wound complication. ‘G’ bone is the better bone substituent and does not carry any infection and disease, prevent the long term tuberosity collapse and maintain calcaneal height and width.

Excellent results in Extensile Lateral approach with plate osteosynthesis it was supported by many studies[19,10].Skin related complication was very less in this approach.

Buckley and meek et al[10] in their comparative study of 34 cases stated that operative treatment yields better outcome provided a anatomical reduction of subtalar joint is achieved in this approach.

Our study with Muller et al regarding comminution. we confirmed the benefit of LCP implanting over the NonLCP for all Sander’s type of intraarticular fractures .The most comminuted fractures in Sanders IV shows

excellent and good results with LCP plate osteosynthesis than with non- LCP treatment.

The most difficult part is to bring the anatomical reduction in Sander's Type IV. It is mostly communited and subtalar joint congruity maintained in intra operative period was difficult[19]. 4 patients had this type of fracture in the study 3 treated with LCP, one patient with Non-LCP. No patient had any skin complications

The number of patients came for postoperative followup in this period was very low.

We have evaluated the radiological parameters at the end of one year, Bohler's angle, Gissane's angle which has statistically significant ,but calcaneal height,width which has statistically insignificant results when LCP group compared with the non LCP group.

Restoration of Bohler's angle and Gissane's angle is associated with excellent results in Locking plate in our study. This fact, proved and verified by a lot of authors, confirmed the role of Bohler's angle size as a predictive factor for subsequent late complications.[10,11]

The AOFAS- Ankle Hindfoot score which evaluates pain, functional ability, cosmesis and range of movements LCP group is better than non - LCP group but statistically insignificant.

When comparison is based on individual fracture patterns with respect to AOFAS Ankle Hindfoot Score, Sanders classification fractures LCP group is better[19] than non –LCP group but it is statistically insignificant.

Sanders type III and severely comminuted type IV fractures LCP group is better. Our study type IV fractures experiences poor results in NLCP. This may be due to subtalar restriction and arthritis, soft tissue impingement and smashed heel pad syndrome[19].Since the fractures are randomised and the NLCP group only one patient had Sander's Type IV, we need more number of patients and followup.

In our study, the AOFAS- Ankle Hindfoot score is 80.666 in LCP group and 71.66 in Non-LCP group.We followed a standard operative protocol,but done by different surgeons and grafting was done in all cases.

# LIMITATIONS

- Our study is limited by less number of patients and a randomized
- Our sample size is small and the mean follow up period is a short and many studies have shown improvement in functional outcome after one year of follow up.
- More over plate osteosynthesis is done by different surgeons and the observer is not blinded.

# CONCLUSION

- Open reduction Internal fixation remains the gold standard treatment for displaced fractures of the calcaneum, since it restores the congruity of the subtalar joint and restores the normal anatomy of the bone.
- Accurate anatomical restoration of the posterior facet is associated with excellent outcome and it should be the primary aim in reduction techniques.
- CT imaging is an essential in pre-operative evaluation of fractures, classification and in planning treatment.
- The complications associated with wound healing can be overcome by extensile lateral approach, delayed intervention after subsidence of edema and meticulous soft tissue handling.
- Bone grafting and bone graft substitutes is recommended in all cases with a void and to prevent post-operative collapse.
- To conclude open reduction and internal fixation with LC plate osteosynthesis provides **excellent and statistically significant results** when compared to non-LCP patients were noted for all intra-articular calcaneal fractures.
- Sander's type IV and severely comminuted intrarticular fractures are not considered to be the contraindication to surgery.

- In Sander's type IV and severely comminuted fractures, though the outcome LCP group is better than non-LCP group is **statistically insignificant** due to short period of follow-up.
- LCP group patient early mobilization with weight bearing walking comparatively in non LCP group patients, implant related complications was less.
- Since the functional outcome of operated patients tends to improve even after one year, we recommend a longer period of follow up of these patients for significant results when compared to the non-LCP group.

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## ANNEXURE: I

## ANKLE-HINDFOOT SCALE(100 POINTS TOTAL)

### I. PAIN(40 POINTS)

| | | |
|---|---|---|
| **1.** | **None** | **40** |
| **2.** | **Mild,occasional** | **30** |
| **3.** | **Moderate, daily** | **20** |
| **4.** | **Severe almost always present** | **0** |

### II.FUNCTION: (50 POINTS)

### a. ACTIVITY LIMITATIONS, SUPPORT REQUIREMENT

| | | |
|---|---|---|
| **1.** | **No limitations, no support** | **10** |
| **2.** | **No limitation of daily activities, limitation of recreational activities, no support** | **07** |
| **3.** | **Limited daily and recreational activities, cane** | **04** |
| **4.** | **Severe limitation of daily and recreational activities,walker,crutches,wheelchair, brace** | **0** |

**b. MAXIMUM WALKING DISTANCE,BLOCKS:**

| | | |
|---|---|---|
| **1.** | **Greater than 6** | **5** |
| **2.** | **4—6** | **4** |
| **3.** | **1-3** | **2** |
| **4.** | **Less than 1** | **0** |

**c. WALKING SURFACES**

| | | |
|---|---|---|
| **1.** | **No difficulty on any surface** | **5** |
| **2.** | **Some difficulty on uneven terrain, stairs, inclines, ladders** | **3** |
| **3.** | **Severe difficulty on uneven terrain, stairs, inclines, ladders** | **0** |

**d. GAIT ABNORMALITY**

| | | |
|---|---|---|
| **1.** | **None, slight** | **8** |
| **2.** | **Obvious** | **4** |
| **3.** | **Marked** | **0** |

**e. SAGITTAL MOTION (FLEXION PLUS EXTENSION)**

| | | |
|---|---|---|
| **1.** | **Normal or mild restriction (30 degree or more)** | **8** |
| **2.** | **Moderate restriction (15-19 degree)** | **4** |
| **3.** | **Severe restriction (less than 150)** | **0** |

**a. HINDFOOT MOTION (INVERSION PLUS EVERSION)**

| | | |
|---|---|---|
| **1.** | **Normal or mild restriction(75%-100% normal)** | **6** |
| **2.** | **Moderate restriction(25%-74%normal)** | **3** |
| **3.** | **Marked restriction (less than 25% normal)** | **0** |

**b. ANKLE – HINDFOOT STABILITY ( ANTEROPOSTERIOR, VARUS-VALGUS)**

| | | |
|---|---|---|
| **1.** | **Stable** | **8** |
| **2.** | **Definitly unstable** | **0** |

**b. ALIGNMENT (10 POINTS)**

| | | |
|---|---|---|
| **1.** | **Good, plantigrade foot, midfoot well aligned** | **15** |
| **2.** | **Fair, plantigrade foot, some degree of midfoot malalignment observed, no symptoms** | **8** |
| **3.** | **Poor, nonplantigrade foot, severe malalignment, symptoms** | **0** |

**ASSESS WOUND HEALING**

**SUBTALAR ARTHRITIS**

**CALCANEAL MALPOSITION/ MALUNION**

**LATERAL/TALOTIBIAL IMPINGEMENT SYNDROME**

**BONE GRAFT REQUIREMENT**

## ANNEXURE II:

## PROFORMA

NAME: AGE:

SEX:

ADDRESS:

I.P NO: UNIT: DOA: DOS:

WARD:

MODE OF INJURY: SIDE:

ASSOCIATED INJURIES:

SANDERS CLASSIFICATION:

ESSEX LOPRESTI CLASSIFICATION:

PAST MEDICAL HISTORY:

INVESTIGATION:

URINE: ALBUMIN, SUGAR, DEPOSITS

BLOOD: HB, UREA, SUGAR, CREATININE, GROUPING &TYPING,VCTC

ECG:

X-RAYS: AP,LATERAL VIEW AND HARRIS AXIAL VIEW OF ANKLE

CHEST PA VIEW

CT CALCANEUM: AXIAL, CORONAL WITH 3 D RECONSTRUCTION

INTIAL MANAGEMENT: BK SLAB,LIMB ELEVATION,NSAIDS

OPERATIVE GROUP /NON OPERATIVE GROUP:

SURGERY AND IMPLANTS:

DATE OF SURGERY: TIME INTERVAL:

PLATE AND SCREWS:

OPERATIVE TIME:

COMPLICATIONS:

SKIN NECROSIS:

MALUNION:

ARTHRITIS:

NEUROLOGICAL:

PERONEAL TENDINITIS:

HEEL EXOSTOSIS:

OTHERS: LEFT

| Month | Ankle dorsiflexion | Ankle plantarflexion | Inversion | Eversion | AOFAS Ankle HIND FOOT SCORE |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

RIGHT

| Month | Ankle dorsiflexion | Ankle plantarflexion | Inversion | Eversion | AOFAS Ankle HIND FOOT SCORE |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

# MASTER CHART

# LCP CASES

| SAMPLE | AGE | SEX | MODE OF INJURY | SANDER'S | ASSOCIATED INJURY | TIME OF SURGERY (D | PRE OP BOHLER | POST OP BOHLER | PRE OP GISSANE | POST OP GISSANE | PREOP HEIGHT | POST OP Ht | PREOP Width | POSTOP Width | GRAFTING | UNION | COMPLIC/ | AHF SCALI | LATE COM | FOLLOW PERIOD | IMPLANT EXIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21 | M | FALL | III | | 12 | 13 | 32 | 128 | 120 | 42 | 46 | 54 | 49 | G BONE | ** | | EXCELLENT | | | |
| 2 | 35 | M | FALL | II | SPINE | 10 | 15 | 28 | 135 | 122 | 44 | 48 | 57 | 50 | G BONE | ** | | EXCELLENT | | | |
| 3 | 33 | M | RTA | IV | | 14 | 12 | 28 | 138 | 124 | 43 | 48 | 60 | 51 | G BONE | ** | | FAIR | | | |
| 4 | 25 | M | RTA | II | | 17 | 16 | 32 | 141 | 120 | 40 | 48 | 58 | 50 | BONE GRAFT | ** | | EXCELLENT | | | |
| 5 | 37 | M | RTA | IV | | 13 | 13 | 26 | 130 | 118 | 39 | 45 | 51 | 48 | G BONE | ** | | GOOD | | | |
| 6 | 31 | F | FALL | IV | | 15 | 12 | 28 | 132 | 122 | 41 | 46 | 53 | 49 | G BONE | ** | | POOR | | | |
| 7 | 36 | M | RTA | III | SUBTROCHANTERIC F | 10 | 8 | 32 | 134 | 118 | 38 | 45 | 56 | 51 | BONE GRAFT | * | SUPERFIC | POOR | | | |
| 8 | 42 | M | FALL | IV | | 18 | 10 | 24 | 136 | 116 | 40 | 47 | 61 | 50 | G BONE | ** | | EXCELLENT | | | |
| 9 | 30 | M | FALL | II | | 19 | 12 | 26 | 128 | 120 | 46 | 48 | 52 | 49 | G BONE | ** | | GOOD | | | |
| 10 | 23 | M | FALL | III | SPINE | 11 | 11 | 26 | 132 | 118 | 44 | 49 | 52 | 50 | G BONE | ** | | GOOD | | | |

# Non-LCP CASES

| SAMPLE | AGE | SEX | MODE OF INJURY | SANDER'S | ASSOCIATED INJURY | TIME OF SURGERY (D | PRE OP BOHLER | POST OP BOHLER | PRE OP GISSANE | POST OP GISSANE | PREOP HEIGHT | POST OP Ht | PREOP Width | POSTOP Width | GRAFTING | UNION | COMPLIC/ | AHF SCALI | LATE COM | FOLLOW PERIOD | IMPLANT EXIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | M | FALL | II | | 12 | 14 | 22 | 132 | 124 | 44 | 46 | 56 | 52 | G BONE | ** | SUPERFIC | EXCELLENT | | | |
| 2 | 34 | M | FALL | II | SPINE | 16 | 16 | 20 | 130 | 122 | 42 | 48 | 58 | 51 | G BONE | ** | | POOR | SUBTALAR ARTHRITIS | | |
| 3 | 37 | M | FALL | III | | 18 | 18 | 22 | 128 | 128 | 43 | 50 | 54 | 51 | BONE GRAFT | ** | | GOOD | | | |
| 4 | 23 | M | RTA | III | | 14 | 17 | 21 | 134 | 126 | 42 | 46 | 60 | 53 | G BONE | ** | | GOOD | | | |
| 5 | 21 | F | FALL | II | | 13 | 15 | 20 | 130 | 136 | 40 | 46 | 50 | 50 | G BONE | ** | | POOR | | | |
| 6 | 40 | M | RTA | II | INTER TROCHANTERI | 14 | 16 | 22 | 132 | 120 | 38 | 46 | 61 | 51 | G BONE | ** | SUPERFIC | EXCELLENT | | | |
| 7 | 28 | M | RTA | III | | 15 | 13 | 20 | 128 | 122 | 46 | 48 | 56 | 51 | G BONE | ** | | POOR | SUBTALAR ARTHRITIS | | |
| 8 | 26 | F | FALL | II | | 17 | 12 | 20 | 136 | 128 | 44 | 48 | 50 | 50 | G BONE | * | DEEP INFE | FAIR | PLATE EXI | AFTER 4 MONTHS | |
| 9 | 29 | M | RTA | III | | 19 | 10 | 18 | 128 | 124 | 39 | 46 | 54 | 50 | BONE GRAFT | ** | OSTEOMY | FAIR | | | |
| 10 | 31 | M | RTA | IV | | 11 | 16 | 22 | 134 | 136 | 42 | 48 | 52 | 50 | G BONE | ** | | POOR | SUBTALAR ARTHRITIS | | |